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INCLUDING

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### NEMATODA.

#### VOL. II.

(FILARIOIDEA, DIOCTOPHYMOIDEA and TRICHINELLOIDEA.)

BY

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## AUTHOR'S PREFACE.

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THIS volume concludes the systematic account of the Nematodes known to occur in India, Ceylon and Burma. The plan followed is the same as in the first volume, and the same sources of information (see vol 1, p viii) have been consulted for the names of hosts, with the addition of the following:

‘Fauna of British India’

Diptera, vol iv, by S R Christophers (1933), and  
vol v, by P J Barraud (1934)

Butterflies, vol ii, by C T Bingham (1907)

A host-list, covering the parasitic forms described in both volumes, has been added

It will be readily understood that it is impossible to ensure the completeness of a work of this kind up to the moment of publication, and that it is not practicable to correct in this volume all the shortcomings of the first. More than three years have elapsed since the publication of that volume, and a number of species would now have to be added to those with which it deals.

The writer wishes to renew the acknowledgments made in the preface to the former volume, and to thank the additional authors and publishers from whom illustrations have been borrowed.

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July, 1939



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*Note*—This list is supplementary to that in Vol I, and the note there printed (p xi) applies equally to it. References in the text of the present volume may be to either of the two lists

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## SYSTEMATIC ACCOUNT OF INDIAN NEMATODES

(continued).

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### Order FILARIOIDEA Weinland, 1858 \*.

*Parasitic forms with paired lateral lips, or with or without prominent lip-like structures. These, if present, are not arranged on a triradiate plan, but are bilaterally symmetrical. Head typically with two lateral and four submedian papillae, some or all of which, however, may be duplicated. Oesophagus without bulb, but usually divided into a muscular anterior portion and a more glandular posterior portion. Caudal end of male without a bursa, but generally provided with lateral alae and with a relatively small number of paired papillae. Spicules usually unequal and dissimilar. The eggs contain embryos when laid, or hatch in utero. The life-history is probably always indirect, an intermediate host being required.*

#### 1. Family FILARIIDÆ Claus, 1885.

*Medium-sized or large forms in which the body is usually elongate and filiform. Male usually considerably smaller than female. Lip-like structures absent or very slightly developed. A buccal capsule is rarely present. Vulva towards the anterior end of the body. Uterine branches parallel. Females viviparous or ovoviviparous. Adult worms in the connective tissue, vascular system or serous cavities of vertebrates. Embryos usually in the blood or lymph of the final host, and transmitted (where the life-history is known) by blood-sucking Arthropods, which serve as intermediate hosts.*

#### Subfamily FILARIINÆ Stiles, 1907

*Head without epaulette-like or trident-like structures. Oesophagus typical. Spicules of male unequal and dissimilar.*

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\* This order, as here understood, includes the superfamilies Filarioidea and Spirurioidea of Railliet and other authors

## Key to Genera

Adults parasitic in mammals	1
Adults parasitic in birds	8
1 Mouth with lip-like structures	2
Mouth without lip-like structures	4
2 Mouth with a circumoral ring, notched so as to form two or four prominences	SETARIA, p 29
Mouth with small, paired, lateral lip-like structures	3
3 Cuticle with numerous papilla-like bosses near anterior end only	PARAFILARIA, p 21
Cuticle with scattered bosses except at the extremities	PAPILLOSETARIA, p 34
4 Spicules of male both of trough-like form	PROTOFILARIA, p 28
Spicules of male dissimilar in form	5
5 Cuticle, at least in female, with annular or spiral thickenings	ONCHOCERCA, p 14
Cuticle without thickenings	6
6 Male with a small accessory piece	WUCHEREBIA, p 11
Male without accessory piece	7
7 Vulva behind œsophagus	DIROFILARIA, p 2
Vulva in front of posterior end of œsophagus	DIPETALONEMA, p 7
8 A small buccal cavity present	HAMULOFILARIA, p 25
Buccal cavity absent	9
9 Spicules of male equal in length	CHANDLERELLA, p 26
Spicules of male unequal in length	APROCTOIDES, p 24

1 Genus **DIROFILARIA** Railliet and Henry, 1911\*

Mouth without lip-like structures Cephalic papillæ inconspicuous Oesophagus relatively short and slender, rather indistinctly divided into anterior and posterior portions Caudal end of male spirally coiled, the tail short and rounded, with slight alæ Caudal papillæ variable in number and usually asymmetrical, including a preanal and adanal group

\* The separation of this genus from *Dipetalonema* is felt to be somewhat unsatisfactory. The species here dealt with can be assigned to one genus or the other on the basis of the position of the vulva, but it appears doubtful whether this criterion would be applicable to all species. Yorke and Mapleson (1926) placed the two genera in different subfamilies (Filarinæ and Setarinæ), apparently because in *Dipetalonema* the cuticle of the head was interpreted as forming a "shield" (or "lateral epaulette-like structures" in these authors' key, p 421). Wehr (1935) goes so far as to erect a new family, *Dipetalonematidæ*, with two new subfamilies, of which these two genera are the types, and to which the following key is given —

" Caudal alæ well developed, œsophagus distinctly divided externally into 2 parts, tail short . . .	DIROFILARINÆ
" Caudal alæ, if present, extremely narrow; œsophagus usually not divided into 2 parts, tail short or long . . .	DIPETALONEMATINÆ "

Wehr does not indicate the contents of the genera as conceived by him, and it seems doubtful to which genus he would assign the forms here described under *Dipetalonema*

of three to six pairs of large papillæ with swollen peduncles. Spicules unequal and dissimilar, the left longer, with a membranous or whiplash-like, pointed, distal portion, the right shorter, trough-like and blunt. Tail of female short and rounded. Vulva postoesophageal. Female viviparous. Microfilaria without sheath, occurring in the blood of the host. Adult worms in the heart, blood-vessels, serous cavities or connective tissue of mammals.

Genotype —*Dirofilaria immitis* (Leidy, 1856)

### Key to Species

Left spicule of male less than 0.4 mm long, with relatively short distal portion	<i>immitis</i> , p. 3
Left spicule more than 0.4 mm long, with long, lash-like distal portion	<i>repens</i> , p. 5

### 1 *Dirofilaria immitis* (Leidy, 1856) Raillet and Henry, 1911. (Figs 1 & 2)

Synonyms —*Filaria canis cordis* Leidy, 1850, *Filaria papillosa hæmatica canis-domestici* Gruby and Delafond, 1852 (nec *F. papillosa* Rudolphi, 1802), *Filaria immitis* Leidy, 1856, *Filaria papillosa hæmatica* Schneider, 1866, *Filaria hæmatica* Leuckart, 1867, *Filaria sanguinis* Cobbold, 1869, *Spiroptera immitis* Ercolani, 1875; *Microfilaria immitis* Neumann and Mayer, 1914, *Dirofilaria indica* Chakravarty, 1936.

**Hosts** —This parasite occurs in dogs, cats and various wild carnivores, and in almost all parts of the world. Its usual

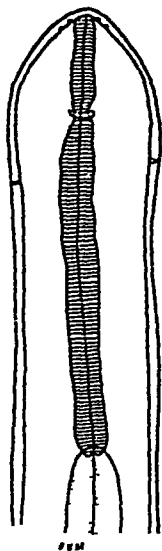


Fig 1 —*Dirofilaria immitis*. Anterior end, ventral view.  
(From Baylis, after Yorke and Maplestone)

habitat is the right ventricle of the heart and the pulmonary artery, where it often forms dense masses, and may cause the death of its hosts. It is also sometimes found in other situations, such as the thoracic cavity and bronchi. The

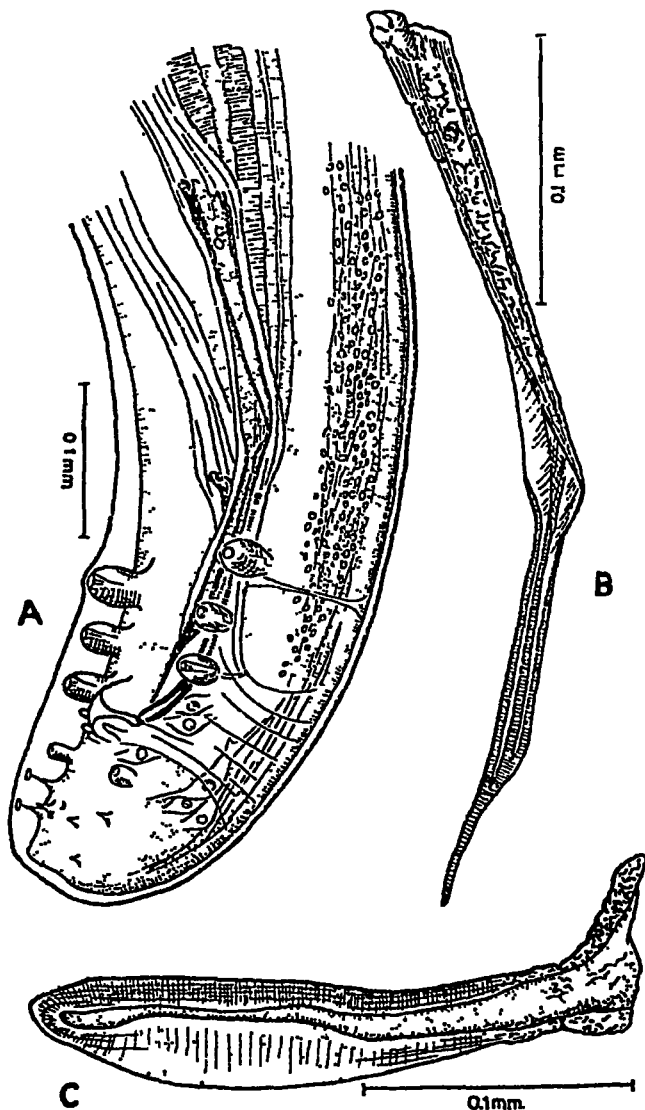


Fig 2—*Dirofilaria immitis* A, posterior end of male, ventro-lateral view; B, left spicule, C, right spicule (After Vogel)

worm has been recorded from dogs in India by several observers, in Burma by Gaiger and in Ceylon by v Linstow

The male measures 120–200 mm in length and 0.6–0.9 mm in maximum thickness, the female 210–320 mm and 1–1.3 mm respectively. The cuticle has fine transverse

striations There are usually said to be two lateral and four submedian cephalic papillæ, but Kreis (1936) describes two crowns of four papillæ each The œsophagus is about 1-1.5 mm long Of this length about 0.56-0.68 mm is occupied by the anterior portion This shows two slight constrictions, the posterior of which is at the level of the nerve-ring (0.3-0.48 mm from the anterior extremity)

The tail of the male is 0.075-0.12 mm long There is a group of 3-6 large papillæ on each side with swollen peduncles Of this group the most posterior is postanal The left group extends further forward than the right, and usually contains one more papilla There are also 5 or 6 pairs of subventral papillæ on the tail Of these the most anterior pair is near the angles of the cloacal aperture, the next a little further back and nearer to the mid-ventral line The more posterior papillæ are variable in number and position Occasionally there is an unpaired terminal papilla (Vogel, 1927) The left spicule measures about 0.3-0.38 mm in length, and has an angular bend at about its middle Its terminal portion is relatively short, almost straight and pointed The right spicule is about 0.167-0.22 mm long, and is broad, trough-like, slightly curved and blunt

The tail of the female is 0.18-0.25 mm long, and bears a pair of small papillæ at its tip Sometimes it appears also to have a sunken terminal papilla The vulva is a transverse slit with slightly thickened lips, situated at about 2.3-3.4 mm from the anterior end The microfilariae measure about 0.15-0.32 mm in length and 5-8  $\mu$  in thickness They show a certain degree of nocturnal periodicity in the peripheral blood of the host

The vectors are numerous species of mosquitoes (chiefly species of *Culex*, *Anopheles*, *Myzorchynchus* and *Aedes*)

## 2 *Dirofilaria repens* Railliet and Henry, 1911 (Fig. 3)

Synonyms —*Filaria repens* Mesnil, 1913, *Filaria* (*Dirofilaria*) *repens* Braun, 1915, ? *Filaria ochmanni* Fülleborn, 1908, ? *Microfilaria ochmanni* Geddoelst, 1911

*Hosts* —This species has been recorded from the dog in Europe, Asia, South America, and (probably) Africa, and from man in Russia It occurs in the subcutaneous connective tissue Panda (1932) has recorded microfilariae, probably belonging to this species, as occurring in the blood of ten per cent of a large number of dogs at Patna

The following description is derived from Railliet and Henry (1911, b), Vogel (1927) and Lent and Teixeira de Freitas (1937) The male measures 48-70 mm in length and 0.37-0.45 mm in maximum thickness, the female 100-170 mm

and 0.45–0.65 mm respectively. Lent and Teixeira de Freitas were unable to detect any cephalic papillæ. The cuticle of the head, according to these authors, is thickened and granular in appearance. The œsophagus consists of two portions, and measures 1.05–1.53 mm in length in the female, the anterior portion being 0.49–0.54 mm long. The nerve-ring is situated, in the female, at 0.304–0.368 mm from the anterior end. Cervical papillæ and an excretory pore were not seen.

The tail of the male is bluntly rounded and 0.072 mm long. There are five or six large, pedunculate preanal papillæ on the left side and from two to five on the right. These diminish in size posteriorly. There are also five or six pairs of smaller

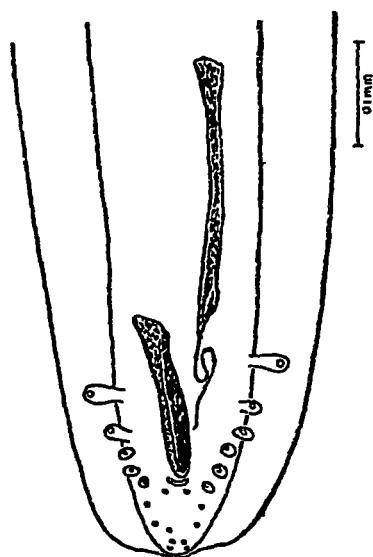


Fig. 3 —*Dirofilaria repens*. Posterior end of male, ventral view (After Vogel.)

adanal and postanal papillæ. The left spicule is 0.43–0.59 mm long, and has a long, flexible, whiplash-like distal portion. The right spicule is about 0.18–0.2 mm long, and is broadly alate.

The tail of the female is blunt and slightly curved ventrally. It measures 0.05–0.09 mm in length, and bears a pair of papillæ at its tip. The vulva is situated at 1.15–1.92 mm from the anterior extremity. The vagina is about 3.4 mm long, and is sometimes convoluted. The microfilariae in the blood of the host measure 0.207–0.36 mm in length and 5–8  $\mu$  in thickness.

The vectors are mosquitoes, and are said to include *Stegomyia fasciata*, *Anopheles maculipennis*, and *Aedes ægypti*.

2 Genus **DIPETALONEMA** Diesing, 1861

Synonyms — *Acanthocheilonema* Cobbold, 1870, *Breinhia* Yorke and Maplestone, 1926, ? *Derañophoronema* Romanovitch, 1916

Mouth without lip-like structures Body slender, usually more tapering posteriorly than anteriorly Cuticle with or without fine transverse striations Head blunt, with two lateral papillæ and four submedian papillæ which may have double terminations Œsophagus usually consists of a relatively short, muscular anterior portion and a long, and stouter, glandular posterior portion Caudal end of male spirally coiled, caudal alæ absent or very narrow Three or four pairs of preanal and two to five pairs of postanal papillæ present Frequently also, near the tip of the tail, a pair of small, conical, lateral appendages Spicules very unequal and dissimilar, the left long, with a stout, tubular proximal portion and a narrow, filamentous or membranous distal portion, the right short, usually much stouter, and variable in shape Tail of female moderately long, usually with a pair of conical appendages near the tip Vulva in front of posterior end of œsophagus Common trunk of uterus long Female viviparous Microfilariae without sheath, occurring in the blood of the host Adult worms in the serous membranes, connective tissue or vascular system of mammals

Genotype — *Dipetalonema gracile* (Rudolphi, 1809)

*Key to Species*

Parasite of dogs	<i>reconditum</i> , p 7
Parasite of camels	<i>evansi</i> , p 8
Parasite of gibbons	<i>digitatum</i> , p 10

1 **Dipetalonema reconditum** (Grassi, 1889) Yorke and Maplestone, 1926

Synonyms — *Filaria recondita* Grassi, in Grassi and Calandruccio, 1889, *Acanthocheilonema reconditum* Railliet, Henry and Langeron, 1912, *Dirofilaria recondita* Neumann and Mayer, 1914

*Host* — This is a parasite of the dog, and was originally recorded from the perirenal fatty tissue of that animal in Italy It has also been recorded from various other organs and tissues, including the vascular system, lungs and liver Rao (1923) records it from Madras, Baluchistan and the Punjab A "Hæmatozoon" recorded by Lewis from the dog in Calcutta was perhaps the microfilaria of this species

The following description is derived partly from Grassi and partly from Noè (1907) The male measures 12 mm in length and 0.1–0.106 mm in maximum thickness, the female

26-30 mm and 0.144-0.157 mm respectively. The body is narrowed to form a "neck" behind the cephalic extremity. This is followed by a cervical swelling at about 0.3 mm from the anterior end. The cephalic papillæ are small. They consist of a lateral pair and two crowns of four submedian papillæ each. The anterior portion of the œsophagus, which has an ovoid bulbous expansion, more conspicuous in the female, at its anterior end, is about 0.4-0.42 mm long. The posterior portion measures about 1.9 mm in length in the male and 1.96-2.4 mm in the female. The cervical papillæ are situated a little behind the cervical swelling, at about 0.4 mm from the anterior extremity. The nerve-ring is at about the junction of the two parts of the œsophagus.

The tail, in both sexes, ends in three cuticular points, one of which is terminal and two lateral. Each of the lateral processes has a papilla at its base. There is also a pair of ventral papillæ in front of the processes. The caudal end of the male forms a spiral of three turns. The tail is about 0.13 mm long. There are 11 caudal papillæ. One of these is unpaired and situated in front of the cloacal aperture. One pair is situated almost on the posterior border of the aperture, and the other four pairs in two series at its sides. The papillæ are, however, somewhat variable in position and also in size. Noë states that one spicule is longer than the other, but does not give their lengths.

According to Grassi, the tail of the female is 0.228 mm long. The vulva is situated at about 0.84 mm from the mouth. The vagina is long and coiled, and has a thickened ovejector near the vulva, with an S-shaped lumen. The uterus divides into two branches at a distance of about 0.82 mm from the vulva. The microfilariae, as found in the blood of the host, measure, according to Grassi, Noë and Rao, from 0.216 mm to 0.28 mm in length and 4.3 to 5.5  $\mu$  in thickness.

The vectors are said to include not only mosquitoes (*Culex fatigans*, *C. quinquefasciatus*) but also lice, fleas, and ticks.

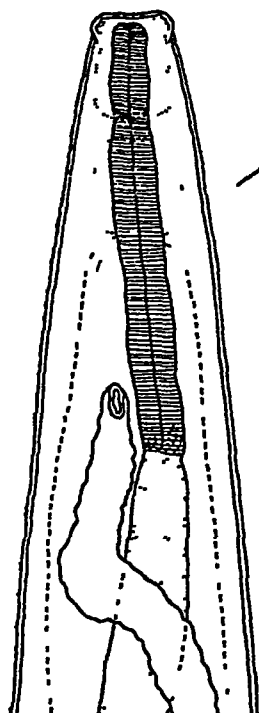
## 2 *Dipetalonema evansi* (Lewis 1882) Yorke and Maplestone, 1926 (Figs 4 & 5)

Synonyms —*Filaria evansi* Lewis, 1882, *Microfilaria camelensis* Balfour, 1911, *Filaria hæmatica cameli* Pricolo, 1913, *Microfilaria evansi* Yakimoff *et al.*, 1916, *Acanthocheilonema evansi* Baylis and Daubney, 1923, *Deratophoronema cameli* Romano vitch, 1916.

*Hosts* —This species occurs in the arteries and in the mesentery of camels. It was first recorded by Lewis from Dera Ismail Khan. Gaiger (1910) states that it is common in India. Baylis and Daubney (1923, b) and Boulenger (1924) have given descriptions based on material from the Punjab.

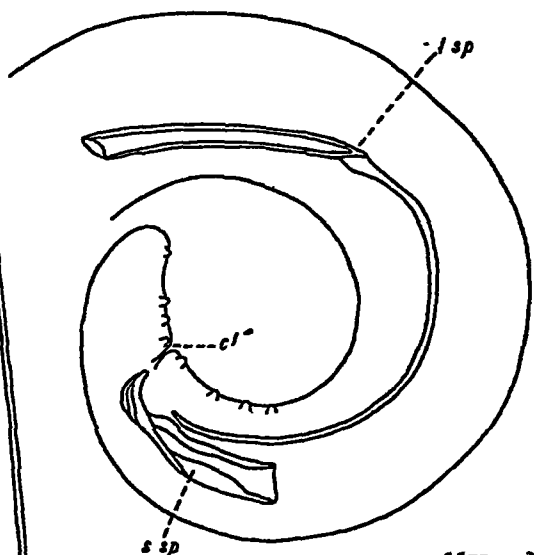
The male measures 75-90 mm in length and 0.25-0.29 mm. in maximum thickness, the female 170-215 mm and 0.55-0.73 mm respectively. The diameter of the head is 0.1-0.11 mm in the male and 0.12-0.14 mm in the female. The anterior end is truncate and dorso-ventrally compressed, and "appears almost oblong when viewed *en face*, owing to the formation of four somewhat laterally directed prominences which bear the submedian papillæ, the latter are double,

Fig 4



0.1mm.

Fig 5



0.1mm.

Fig 4—*Dipetalonema evansi* Anterior end of female, ventral view.  
(After Boulenger, in 'Parasitology')

Fig 5—*Dipetalonema evansi* Posterior end of male, lateral view.  
*cl*, cloacal aperture; *l.sp*, left spicule, *s.sp*, right spicule  
(After Boulenger, in 'Parasitology'.)

there being 10 head-papillæ in all, 2 lateral and 8 submedian" (Boulenger). The lateral papillæ are much larger than the others (Enigk, 1933). The oesophagus is about 5.25 mm long in the male and 6.25-6.7 mm in the female. Of this length, its anterior portion occupies 0.55 mm in the male and 0.75-

0.8 mm in the female. The nerve-ring is broad, and is situated at about 0.2 mm from the anterior end. The slender cervical papillæ are just behind it.

The male is without caudal alæ. The tail is 0.075–0.1 mm long, and has a bluntly rounded tip. There are four pairs of preanal and four pairs of postanal papillæ. The left spicule measures 0.75–1 mm in length. Its slender distal portion is longer than the proximal portion. The right spicule is 0.175–0.19 mm long, and is darker in colour than the left, stout and irregular in shape, with a rough ventral surface.

The tail of the female is about 0.24–0.3 mm long, blunt, and provided near the tip with a pair of very low, broad processes which, in lateral view, cause the tip to appear obliquely truncate. The vulva is situated at 0.57–0.65 mm. from the anterior end. The branches of the uterus originate at about 3.9 mm from the head. The microfilariae found in the blood of camels measure, according to Yakimoff *et al* (1916) and other observers, 0.184–0.266 mm in length and 5.68–8.1  $\mu$  in thickness. They have a blunt head and a tapering tail.

### 3 *Dipetalonema* (?) *digitatum* (Chandler, 1929)

Synonym — *Dirofilaria digitata* Chandler, 1929

*Hosts* — This species was recorded by Chandler from the abdominal cavity of the hoolock gibbon (*Hylobates hoolock*) in the Zoological Gardens, Calcutta Sandground (1933) has also recorded it from *Hylobates leucogenys* in Annam, but gives no further description.

The male is unknown. The female measures 170–210 mm. in length and about 0.38 mm in maximum thickness. Both ends of the body are very slender and tapering. The cuticle is unstriated. The diameter of the head is about 0.055–0.06 mm. The oesophagus measures 1.1–1.3 mm in length, and is very slender (about 11–12  $\mu$  in diameter). It is not very sharply marked off from the intestine, the anterior portion of which is tapering. The nerve-ring is situated at about 0.16 mm from the anterior end.

The tail is about 0.33 mm long, and is cylindrical, with a blunt tip bearing two pairs of digitiform papillæ. The vulva is in the form of a longitudinal slit with slightly prominent lips, and is situated just in front of the junction of the oesophagus and intestine. The vagina has a very thick muscular wall and a narrow lumen near the vulva, but the wall becomes thinner and the lumen wider posteriorly. The uterine branches originate at a distance of about 4–5 mm from the anterior extremity, and the ovaries extend almost as far as the anus.

### 3 Genus **WUCHERERIA** da Silva Araujo, 1877, of Seurat, 1921

Mouth circular, without lip-like structures Body tapering anteriorly Cuticle smooth Head distinct, rounded, followed by a narrower neck Two crowns of cephalic papillæ present Oesophagus rather indistinctly divided into a short anterior and a longer posterior portion Caudal end of male rather sharply curved ventrally and provided with alæ, the tail digitiform A number of pedunculate and sessile preanal and postanal papillæ present Spicules unequal and dissimilar, the longer cylindrical and tapering distally to form a long lash with delicate alæ and having a spoon-shaped termination, the shorter relatively stout, uniform in width and gutter-like, coarsely marked distally A small accessory piece present, crescentic in optical section Tail of female rather long, bluntly rounded Vulva behind the middle of the oesophagus Vagina long, with a pyriform terminal ovejector Female viviparous Microfilariae with sheath, occurring in the blood of the host Adult worms in the connective tissue of mammals

Genotype — *Wuchereria bancrofti* (Cobbold, 1877)

#### 1 *Wuchereria bancrofti* (Cobbold, 1877) Seurat, 1921 (Fig 6)

Synonyms — *Filaria sanguinis hominis* [Lancet], 1872, *Filaria bancrofti* Cobbold, 1877, *Filaria wuchereria* dos Santos, 1877; *Wuchereria filaria* da Silva Araujo, 1877, *Filaria wuchereri* da Silva Lima, 1877, *Filaria sanguinis hominis nocturna* Manson, 1891, *Microfilaria nocturna* Shipley and Fearnside, 1906, *Filaria philippinensis* Ashburn and Craig, 1906, *Microfilaria bancrofti* Manson, 1907; *Microfilaria philippinensis* Ashburn and Craig, 1909, ? *Filaria dermatemica* da Silva Araujo, 1875, ? *Filaria sanguinis* v. Beneden, 1878, ? *Filaria powelli* Penel, 1905, ? *Microfilaria powelli* Castellani and Chalmers, 1910

*Host* — This is a widely-distributed parasite of man, occurring in almost all tropical and subtropical parts of the world, including India and Ceylon, where infestation is common, more especially in the coastal regions and at low altitudes An incidence of 14 per cent of the general population (mainly agricultural) was found in Bihar and Orissa by Korke (1927–1933), of 10.5 per cent in the city of Trivandrum, Travancore, by Iyengar (1933), and of approximately 5 per cent in the Southern Province of Ceylon by Sweet and Dirckze (1934) No evidence of the existence of filariasis in the Punjab or Sind was obtained by Korke (1932, 1933) The term “filariasis,” as applied to man, may generally be taken to mean infestation with *W. bancrofti* The adult worms occur in the glands of the lymphatic system, and sometimes

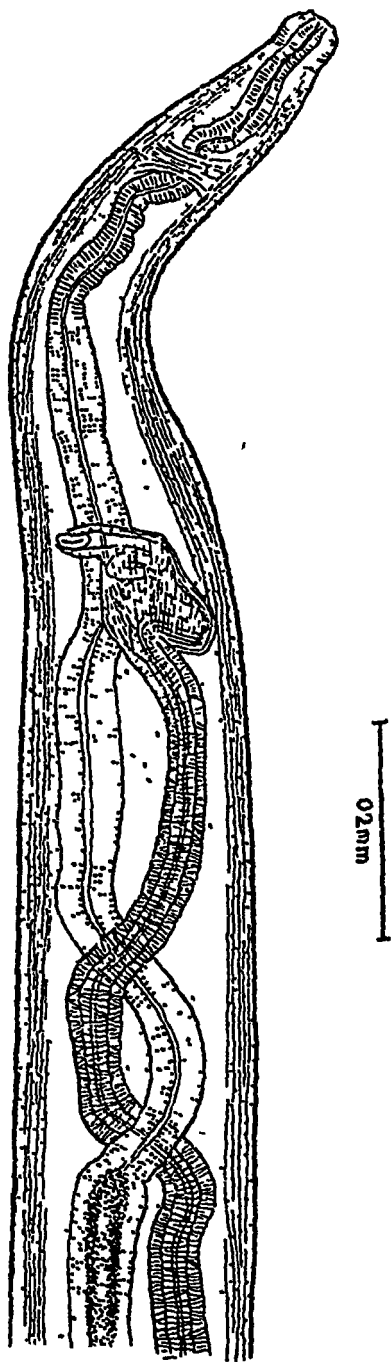


Fig 6 — *Wuchereria bancrofti* Anterior end of female  
latero-ventral view (After Vogel )

also in various internal organs and in abscesses. According to Romiti, their most usual habitat is a varicolymphocoele of the spermatic cord in males, or of the utero-ovarian plexus in females.

The male measures 25–45 mm in length and 0.1–0.15 mm in maximum thickness, the female 50–100 mm and 0.128–0.3 mm, respectively. The oesophagus is about 1.1–1.3 mm long, its anterior, muscular portion measuring between 0.3 and 0.4 mm. The nerve-ring and excretory pore are situated (in the female) at about 0.18 mm from the anterior end.

The tail of the male is about 0.11–0.13 mm long. The cuticle of the ventral surface in the preanal region is transversely striated. The caudal papillae are apparently rather variable in number. There is on each side a regular series of pedunculate papillae, four of which are immediately behind the cloacal aperture and from five to eight preanal. There may be two pairs of rather large, sessile papillae further back on the tail, and one or two pairs of minute subterminal papillae. Maplestone (1929, c) describes, in addition, a pair of relatively large, "flap-like," subventral, adanal papillae. The longer spicule is 0.43–0.6 mm long, the shorter 0.2–0.21 mm. The accessory piece is crescentic in lateral view and U-shaped in transverse section.

The tail of the female is about 0.17–0.3 mm long. The vulva is situated at 0.4–1.3 mm from the anterior extremity. The ovejector is 0.12–0.25 mm long, and has a coiled lumen. The ovarian tubes extend to within 1–4.8 mm. of the posterior end of the body. The egg-membranes, at first measuring about  $0.038 \times 0.025$  mm, ultimately become elongated into sheaths longer than the embryos. The microfilariae, which display a nocturnal periodicity in the peripheral blood of the host, measure about 0.127–0.32 mm in length and  $6.6\text{--}10\mu$  in thickness. They have a bluntly rounded anterior end and a tapering tail. The anterior extremity is retractile within a prepuce-like cuticular fold, and contains a protrusible stylet.

The vectors are mosquitoes of numerous species, belonging principally to the genera *Culex*, *Anopheles* and *Aedes*. In India the commonest vector appears to be *Culex fatigans*, but others, according to Rao and Iyengar (1932), are *Anopheles philippinensis* and *A. ludlowi* var. *sondaica*.

The life-history of *W. bancrofti* is, briefly, as follows — If blood containing microfilariae is ingested by a mosquito, the embryos escape from their sheaths in the stomach of the insect within an hour or two. Within twenty-four hours they migrate from the stomach to the thoracic muscles, where they become quiescent and undergo considerable changes in form, becoming shorter and stouter, and finally sausage-shaped.

Within a week an œsophagus and an intestine are differentiated, and a body-cavity makes its appearance. During the following week a moult takes place, and the larvæ increase greatly in size and become active again. Their development in the mosquito is completed in twelve to twenty days, and they then migrate from the thorax, mainly towards the head. Many of them pass down the labium, and when the mosquito bites a human being they emerge from it on to the surface of the skin. Into this they penetrate by active boring (not through the puncture), and ultimately arrive in some part of the lymphatic system, where they grow to sexual maturity. The connection between infestation with this parasite and the causation of elephantiasis and other pathological conditions is not yet fully understood.

#### 4 Genus **ONCHOCERCA** Diesing, in Hermann, 1841.

Mouth without lip-like structures. Body very elongate and thread-like. Cuticle relatively thick, with transverse striations and also, at least in the female, with raised transverse thickenings which are often interrupted at the lateral fields, and may have the appearance of being spirally arranged. Head with a pair of lateral papillæ and eight submedian papillæ, arranged in two crowns, those of the outer crown being larger than those of the inner. Œsophagus relatively short, more or less distinctly divided into an anterior and a posterior portion, the latter sometimes slightly swollen posteriorly. Caudal end of male spirally coiled. Caudal alæ very narrow. Papillæ variable in number and arrangement, and frequently asymmetrical. Spicules unequal, the left longer than the right and divided into a more heavily chitinated, tubular proximal portion and an alate distal portion, with the alæ rolled into a tube and tapering to a point, the right spicule also tubular, ending in a somewhat knob-like thickening which forms a transverse ridge or barb on the dorsal surface. Tail of female bluntly conical, with a pair of minute papillæ at the tip. Vulva in the region of the posterior end of the œsophagus. Female viviparous. Microfilariae without sheath. Adult worms in the subcutaneous and intermuscular connective tissue and ligaments, or in the walls of blood-vessels, of mammals, sometimes in dense fibrous nodules in the interior of which several worms may occur together.

Genotype —*Onchocerca reticulata* (Diesing, in Hermann, 1841).

From the systematic standpoint this genus is one of the most difficult among the Nematodes. Difficulty in distinguishing between the species arises from two causes—firstly the

extreme difficulty of obtaining complete specimens (owing partly to their great length and fragility, and partly to the density of the tissues that they commonly inhabit), and secondly the scarcity of constant morphological characters which can be used for specific discrimination. The utmost care and patience in dissection are essential if specimens other than mere fragments are to be procured, though some assistance may be obtained from the use of various digestive processes for softening the nodules or "worm-nests" in which the worms so often occur. As regards their morphological characters, many of the supposed species are so much alike, and show so similar a range of individual variation, that Sandground (1934), reviewing a dozen forms described in the literature and definitely attributable to the genus, and having before him material of eight of them, was able to find what he considered reliable distinguishing features for only three species.

Provisionally, the species of this genus known to occur in the Indian fauna may be reduced to five. At least two of these are of very doubtful validity, and are based rather on host and habitat than on definite morphological characters.

### Key to Species

Parasite of Equidæ . . . . .	<i>reticulata</i> , p. 15
Parasite of camels . . . . .	<i>fasciata</i> , p. 21
Parasites of cattle . . . . .	1.
1 Adults in wall of aorta . . . . .	<i>armillata</i> , p. 20
Adults in connective tissue . . . . .	2
2 In subcutaneous and intermuscular tissue, usually in nodules . . . . .	<i>gibsoni</i> , p. 18
In connective tissue between stomach and spleen . . . . .	<i>lienalis</i> , p. 19

### 1 *Onchocerca reticulata* Diesing, in Hermann, 1841. (Figs 7 & 8)

**Synonyms** —*Trichina reticulata equi-caballi* Diesing, in Hermann, 1841, *Filaria reticulata* Creplin, 1846, *Trichina reticulata* Diesing, 1851, *Spiroptera cincinnata* Ercolani, 1866, *Filaria cincinnata* Zürn, 1882; *Spiroptera reticulata* Railliet, 1885, *Onchocerca cervicalis* Railliet and Henry, 1910

**Hosts** —This is a parasite of Equidæ (horse, donkey and mule), and has been recorded in various parts of the world, chiefly in Europe and North America. It occurs in the connective tissue, especially in the flexor tendons of the foot and in the suspensory ligament of the fetlock, usually in the foreleg, producing fibrous nodules which frequently cause lameness. The form occurring in the cervical ligament and known by the name of *O. cervicalis* is considered by some veterinarians to be the cause of fistulous withers and poll evil.

Gaiger (1910) has recorded lesions, probably caused by *O reticulata*, in the tendons of horses in India

If we accept the view of Sandground (1934) that *O cervicalis* is probably to be regarded as a synonym of *O reticulata*,

Fig 8

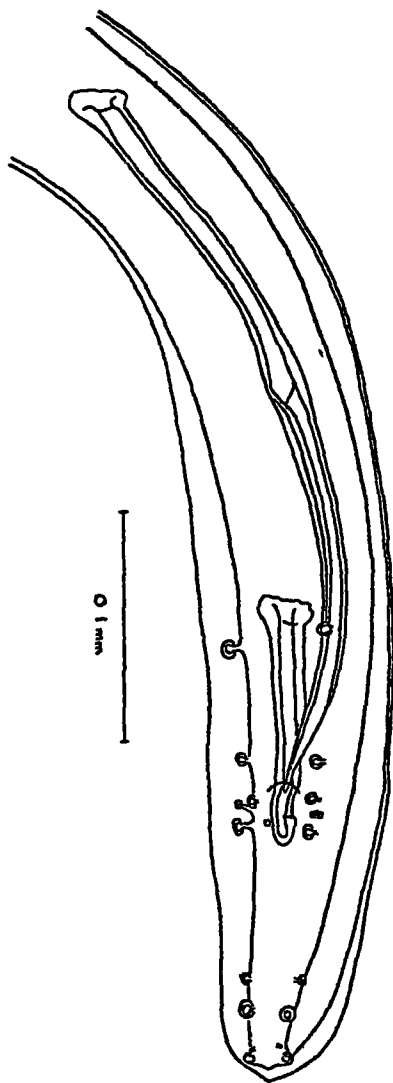


Fig 7.

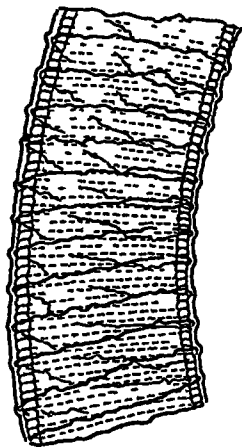


Fig 7.—*Onchocerca reticulata* Portion of body of female, showing spiral markings of cuticle (From Bayhs, after Railhet)

Fig 8—*Onchocerca reticulata* Posterior end of male, ventral view. (Original)

and take together the descriptions of Ackert and O'Neal (1930) and Steward (1933), besides those of Pader (1901)

and earlier authors who have dealt with *O. reticulata*, a tolerably complete account of this species can be given.

The male varies in length from about 60 to 270 mm or more, and has a maximum thickness of 0.07–0.2 mm. Probably no complete specimen of the female has ever been obtained, but its length appears to be from 300 to 750 mm or more, and its maximum thickness about 0.15–0.4 mm. According to Ackert and O'Neal the spiral cuticular ridges, in the middle region of the body, are at intervals of four secondary striations. According to Steward, the ridges are 0.03–0.06 mm apart. The oesophagus measures about 1.45–2.6 mm in length in the male and about 2–3.5 mm in the female. The nerve-ring, according to Ackert and O'Neal, is situated at 0.126–0.277 mm from the anterior end.

The caudal end of the male has fairly well-developed lateral alae. The tail is about 0.115–0.13 mm long. There are, according to the writer's observations on Steward's material, ten pairs of caudal papillae and apparently an unpaired, lozenge-shaped precloacal papilla. The normal arrangement seems to be as follows:—(1) a pair of vaguely-defined papillae at the extreme tip of the tail, (2) close in front of this three pairs, the middle pair large and the others small, (3) a row of four papillae on each side in the cloacal region, of which three are postanal and one preanal, (4) a pair of small sub-ventral papillae behind the cloacal aperture, (5) a pair of large lateral papillae some distance in front of the adanal group, (6) the unpaired precloacal papilla\*. There is, however, some variation and irregularity in the disposition of the papillae. The left spicule measures about 0.2–0.35 mm in length, and is divided at about its middle into a tubular proximal portion and a more membranous distal portion ending in a sharp point. The right spicule is about 0.09–0.12 mm long, and is a rather stout, tubular structure with a slight barb, or transverse ridge-like thickening, on its dorsal side a little in front of the tip.

The tail of the female is about 0.23–0.27 mm long. Ackert and O'Neal figure a group of three papillae at its tip. The vulva is situated at about 0.4–0.8 mm from the anterior end. The eggs, when fully developed and containing embryos, measure about 0.035–0.05 × 0.021–0.035 mm. The microfilariae are about 0.16–0.26 mm long and 2–7  $\mu$  thick. They occur in the skin of the host ("in the subcutis, adjacent to and immediately beneath the glandular layer," according to Steward).

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\* Sandground finds a pair of papillae, in some specimens, immediately in front of the cloacal aperture.

Steward (1933) has found that in England midges of the genus *Gulicoides* (*G. nubeculosus*, and probably also *G. obsoletus* and *G. parroti*) act as vectors (of *O. cervicalis*), the development of the larvæ and their migration to the proboscis of the midge taking 24–25 days

## 2 *Onchocerca gibsoni* (Cleland and Johnston, 1910) Cleland and Johnston, 1911

Synonyms — *Filaria gibsoni* Cleland and Johnston, 1910, *Filaria* (*Onchocerca*) *gibsoni* Cleland and Johnston, 1910, *Onchocerca indica* Sweet, 1915

*Hosts* —The view of Sandground (1934) that *Onchocerca indica* is identical with *O. gibsoni* seems to be well founded. If this be so, the hosts of this species include domestic cattle (*Bos taurus* and *Bos indicus*) and the buffalo (*Bos bubalus*), and its geographical range includes India, the whole of the Malay region and archipelago, and Australia. There are records of its occurrence in Madras, Central Provinces, United Provinces and the Punjab, and of its probable occurrence in Ceylon. The worm inhabits the subcutaneous and intermuscular connective tissue of its hosts, and commonly causes the formation of nodules or "worm-nests"

The following description is derived mainly from Johnston and Cleland (1910), Breinl (1913), Sweet (1915), Johnston (1921) and Sandground (1934)

The male measures 29–93 mm in length and 0.12–0.22 mm in maximum thickness, the female about 520–1570 mm and 0.35–0.63 mm respectively. The transverse ridges of the cuticle in the male are about 5–6  $\mu$  apart, in the female about 50–138  $\mu$ . According to Johnston there are, in the female, two striations between adjacent ridges in the middle region of the body. Sandground, however, states that he was unable to find any striations. The oesophagus measures about 0.48–1.22 mm in length in the male and about 0.5–1.44 mm in the female. The nerve-ring is situated at about 0.1–0.2 mm, and the excretory pore at about 0.175–0.29 mm, from the anterior extremity.

The caudal alæ of the male are not highly developed. The tail is about 0.05–0.1 mm long. The papillæ appear to vary from six to nine on each side, and show much asymmetry and variation in their arrangement. Generally speaking, from three to five papillæ on each side form a group in the region of the cloacal aperture (partly preanal and partly postanal), while the rest are situated on the posterior half of the tail, and include from one to three small papillæ near the tip. The left spicule measures 0.14–0.274 mm in length and ends in a point; the right spicule has a swollen tip marked off

by a dorsal notch, forming a slight barb, and is 0.063–0.122 mm long.

The tail of the female measures about 0.12–0.4 mm in length. The vulva is situated at about 0.33–1.42 mm from the anterior end. The eggs, containing embryos, measure about 0.025–0.045 × 0.017–0.039 mm. The free embryos (in utero) measure about 0.12–0.35 mm in length and 2–4  $\mu$  in thickness.

### 3 *Onchocerca lienalis* (Stiles, 1892) Geddoelst, 1911

Synonym — *Filaria lienalis* Stiles, 1892

**Hosts** — Cattle. This species was originally recorded as occurring in *Bos taurus* in the United States of America. Gaiger (1915) referred to it specimens from cattle in the Punjab, United Provinces and Ceylon. Johnston (1921) states that this worm is "extremely common" in cattle in Queensland. The female is "readily overlooked owing to its location in the connective tissue between the stomach and the spleen, especially adjacent to the latter, where the tunnel enclosing the parasite, if noticed, would easily be mistaken for an empty blood-vessel." The male apparently inhabits serous spaces, not "tunnels," in the connective tissue.

Stiles (1892) merely mentioned '*Filaria lienalis* sp. nov.' in MS., a long thin worm in the connective tissues between the spleen and stomach." According to Sandground (1934) both the manuscript description and the original material were lost. Any subsequent identification of the parasite must therefore be nothing more than conjecture, and could only be based on the habitat. Railliet and Henry (1910, d) first suggested that the species might belong to the genus *Onchocerca*. Material from cattle in Queensland was attributed to *O. lienalis* by Johnston (1921), who gave a description which can be somewhat amplified from data given by Sandground. The latter author, however, rightly regards *O. lienalis* as a species of doubtful validity.

The male, according to these observers, measures about 24–38 mm in length and 0.05–0.1 mm in maximum thickness, the female 316–460 mm or more and 0.18–0.4 mm respectively. The anterior end is extremely slender, the head of the female measuring about 0.03 mm in diameter. According to Johnston, the transverse ridges of the cuticle are very minute and close together (about 2  $\mu$  apart) in the male. In the female they are very low, irregularly wavy, and in the middle region of the body fairly regularly spaced at intervals of 30–40  $\mu$ , with two striations between adjacent ridges. The oesophagus is about 0.75–1.1 mm long, and its maximum thickness

is 0.02–0.025 mm. The nerve-ring is situated at 0.13–0.18 mm from the anterior end.

The caudal end of the male is provided with narrow alæ. The tail is 0.06–0.065 mm long. According to Johnston there are four pairs of "preanal" (or rather adanal) papillæ, of which the first (i.e. most anterior), second and fourth are large, the third quite small and more ventrally situated, a pair of large "caudal" papillæ, very close together, and apparently also a pair of very small papillæ, ventrally situated, just behind the adanal group. Sandground's figures do not show this, but indicate three pairs of papillæ, varying considerably in arrangement, behind the adanal group. The spicules, according to Johnston, are "of the usual *Onchocerca* form". The left spicule, according to Sandground, measures 0.205–0.3 mm, the right 0.057–0.085 mm in length.

The tail of the female is 0.12–0.13 mm long, is bluntly rounded, and carries a pair of very minute papillæ. The vulva is situated at 0.37–0.52 mm from the anterior extremity. The eggs, containing embryos, measure  $0.038\text{--}0.04 \times 0.028\text{--}0.03$  mm. The free embryos (*in utero*) measure 0.24 mm in length and  $4\mu$  in thickness.

#### 4 *Onchocerca armillata* Raillet and Henry, 1909

*Hosts* —This species occurs in the ox, zebu and buffalo in various Oriental countries and in Africa. It lives under the lining of the aorta, in the wall of which it forms sinuous galleries and sometimes nodules. It was first described, but not named, by Lingard in India. Bhalariao (1935, *b*) records it from Madras.

The following description is derived from Lingard (1905), Raillet and Henry (1910, *d*; 1912, *d*), Raillet, in Combes and Devanille (1917), and Sandground (1934).

The male measures 42–90 mm in length and 0.15–0.19 mm in maximum thickness, the female up to 730 mm and about 0.34–0.45 mm respectively. The cuticle of the male has transverse striations  $11\text{--}12\mu$  apart. In the female there are markedly sinuous transverse ridges at intervals of  $40\text{--}45\mu$ , or of three to four striations. The length of the oesophagus is 2.7–3.1 mm in the male and 3.3–3.8 mm in the female.

The caudal end of the male is provided with alæ, which appear to be unusually wide posteriorly. The tail is 0.155–0.17 mm. long. According to Lingard, there are eight pairs of caudal papillæ, of which two are preanal and six postanal. The number and arrangement of the papillæ, however, appear to be very variable, and those of the two sides are frequently asymmetrical. Raillet and Henry found on each side a group of four adanal papillæ, one or two near the tip of the tail, and one about mid-way between these and the

adanal group This last papilla was often absent on one side. In the specimen figured by Railliet there appear to be six pairs of postanal papillæ (the most anterior of these on the right side being adanal), while there are five preanal papillæ on the left and three on the right The left spicule is pointed and measures 0.195–0.28 mm in length, the right spicule measures 0.116–0.136 mm, and has a swollen tip and a recurrent lateral barb

The vulva is situated at 0.72–1.3 mm from the anterior end The eggs, containing embryos, measure 0.05–0.072 × 0.038–0.049 mm According to Railliet and Henry, they frequently show a small point at one pole The free embryos (*in utero*) measure 0.23–0.3 mm in length and 5–7  $\mu$  in thickness, and have a rounded head and a rather rapidly tapering and pointed tail

### 5 *Onchocerca fasciata* Railliet and Henry, 1910

*Host* —This form, which is known only from fragmentary specimens, occurs in the subcutaneous connective tissue of camels (*O. dromedarius*) It was first obtained by Leese from a nodule under the skin of the head of a camel in the Punjab, and later recorded in Australia and Egypt, while Badanine (1938) has recently recorded it from 'the *ligamentum nuchæ* of the camel in Turkmenia

The length of complete worms is unknown The thickness of the female is stated to be 0.4–0.475 mm The transverse ridges of the cuticle, according to Johnston (1921), are irregularly sinuous and knobbed, and are at intervals of 70–90  $\mu$  Between adjacent ridges there are from two to four striations The oesophagus of the female measures 1.6 mm in length, according to Badanine

The tail of the male, according to this author, is 0.098 mm. long The longer spicule is slender and measures 0.315 mm. in length, the shorter spicule is relatively stout and 0.095 mm. long

Badanine states that the tail of the female frequently has a button-like termination The free embryos (*in utero*) measure 0.18–0.23 mm in length and 3  $\mu$  in thickness

### 5 Genus *PARAFILARIA* Yorke and Maplestone, 1926

Mouth with a pair of small, lateral, lip-like structures Cuticle transversely striated except near the anterior extremity, where it bears numerous transverse rows of circular or elliptical papilla-like bosses Oesophagus relatively very short and not divided into two portions Caudal end of male loosely coiled, tail short and bluntly rounded Short caudal alæ present About twelve pairs of caudal papillæ present,

four or five pairs of which, near the cloacal aperture, project into the alæ Spicules unequal and dissimilar, the left long, slender and pointed, the right short, stout and blunt Posterior end of female bluntly rounded Anus subterminal, apparently non-functional Vulva near the mouth Female said to be oviparous [<sup>2</sup> ovoviviparous] Adult worms in the subcutaneous and intermuscular connective tissue of Equidæ

Genotype — *Parafilaria multipapillosa* (Condamine and Drouilly, 1878)

1 *Parafilaria multipapillosa* (Condamine and Drouilly, 1878)  
Yorke and Maplestone, 1926 (Figs 9 & 10)

Synonyms — *Filaria multipapillosa* Condamine and Drouilly, 1878, *Filaria hæmorrhagica* Raillet, 1885, *Setaria hæmorrhagica* Stephens, in Fantham, Stephens and Theobald, 1916, *Microfilaria hæmorrhagica* Romanovitch, 1916, [not *Filaria multipapilla* Molin, 1858]

*Hosts* — This is a parasite of the horse, donkey and mule, and occurs chiefly in Oriental countries It has been recorded by Gaiger and others in India Gulati (1934) has recorded it also in cattle in India, but it seems possible that this record may refer to a different worm In equine animals the parasite inhabits the subcutaneous and intermuscular tissue, and is the cause of a condition known as hæmorrhagic filariasis or parasitic dermatorrhagia Slightly raised nodules, containing the adult worms, appear beneath the skin, and these break down and produce local hæmorrhages

The following description is derived mainly from Raillet and Moussu (1892) The male measures about 28 mm. in length and 0.26–0.28 mm in maximum thickness, the female 40–56 mm and 0.42–0.44 mm respectively The body is a little more tapering posteriorly than anteriorly The cuticle shows fine transverse striations The oesophagus is short, slender and almost cylindrical The nerve-ring is situated at about its posterior third The intestine is much wider than the oesophagus

The tail of the male is about 0.06 mm long There are three pairs of small, subventral papillæ behind the cloacal aperture, and a series of eight or nine pairs of larger and more lateral papillæ (in the specimen described by Raillet and Moussu there were eight such papillæ on the left side and nine on the right, the extra papilla being very small and situated at some distance in front of the rest) The most posterior pair of lateral papillæ is postanal, the next adanal and the rest preanal The left spicule is 0.68–0.75 mm long, slender (8–12  $\mu$  thick) and finely pointed The right spicule measures 0.13–0.14 mm in length and 14–17  $\mu$  in thickness, and has a blunt tip

In the female, according to Yorke and Maplestone, the anus and the posterior portion of the intestine are atrophied. The vulva, which is prominent, is situated near the mouth. The eggs, containing embryos, measure  $0.025-0.058 \times 0.024-0.033$  mm. The embryos, which probably hatch *in utero*, measure  $0.22-0.23$  mm in length and  $9-11 \mu$  in thickness.

Fig 9

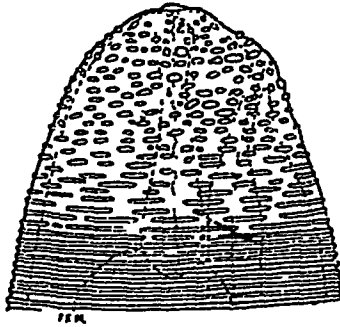


Fig 10

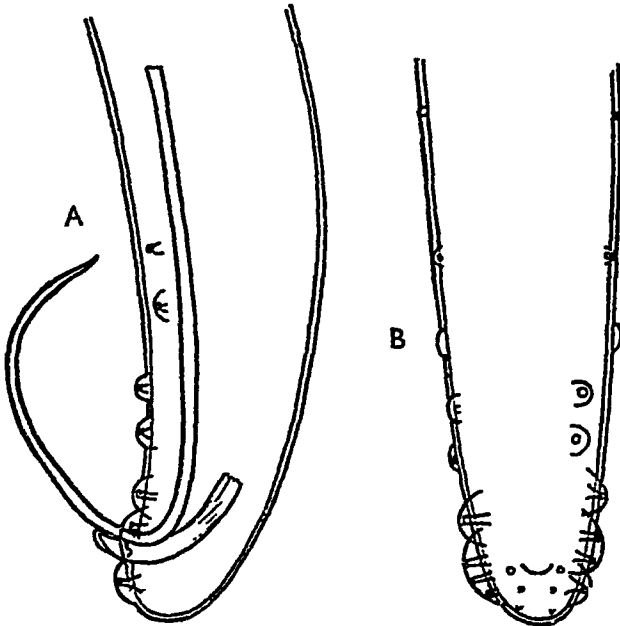


Fig 9—*Parafilaria multipapillosa*. Anterior end of female, lateral view (From Baylis, after Yorke and Maplestone.)

Fig 10—*Parafilaria multipapillosa*. Posterior end of male. A, lateral view, B, ventral view (From Yorke and Maplestone, after Railliet and Moussu.)

6 Genus **APROCTOIDES** Chandler, 1929

Mouth with very flat, inconspicuous lips\*. Cuticle unstriated. Œsophagus short, divided into a very short anterior portion and a longer posterior portion. Caudal end of male spirally coiled; tail short and rounded, without alæ and apparently without papillæ. Cloacal aperture on a conspicuous prominence. Posterior part of intestine slender but not atrophied. Spicules short, unequal but similar in form. Female unknown. Adults in the orbital cavity of birds.

Genotype —*Aproctoides lissum* Chandler, 1929

1 *Aproctoides lissum* Chandler, 1929 (Fig 11)

Host —Dhyal bird or magpie robin (*Copsychus saularis*) (orbital cavity), Zoological Gardens, Calcutta

The female is unknown. The male measures 12 mm in length and about 0.35 mm in maximum thickness. Both

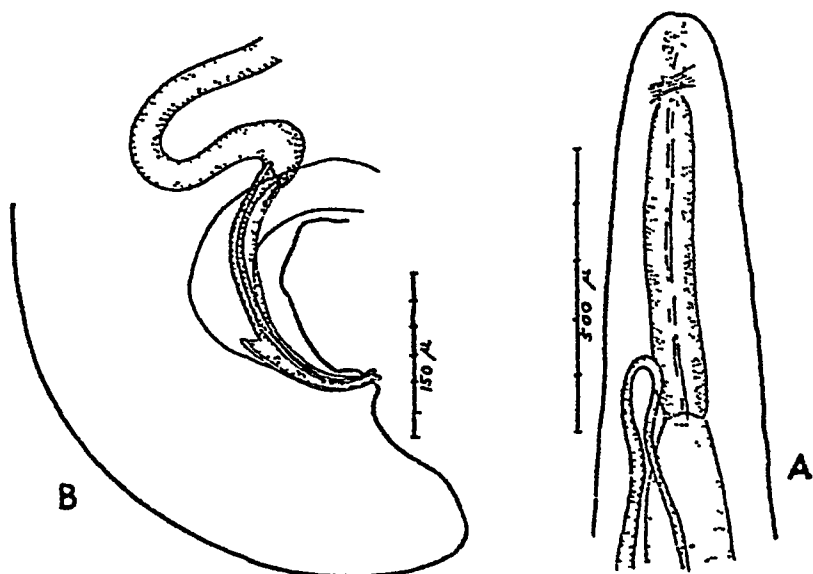


Fig 11 —*Aproctoides lissum*. A, anterior end of male, B, posterior end of male, lateral view (After Chandler)

ends of the body are bluntly rounded. The anterior portion of the Œsophagus is 0.155 mm long, and the posterior portion 0.375 mm. The latter has a uniform diameter of 0.105 mm.

The tail measures 0.145 mm in length. The spicules are much broader proximally than distally, and their sides are rolled inwards so as to form troughs. The left spicule is about 0.3 mm long, the right about 0.13 mm. The genital tube is much convoluted.

\* According to Chandler, there are three lips.

7 Genus *HAMULOFILARIA* Chandler, 1924

Head blunt, without lips, but with four papillae surrounding the mouth. A small buccal cavity present, with a thickened wall. Caudal end of male bent ventrally into a hook and sharply pointed, without alae. On the ventral surface of the tail, near the tip, a roughened callosity. Spicules unequal and dissimilar, the longer shaped like a curved surgical needle, the shorter trough-like, with a pair of ventral barbs near the tip. Female unknown. Adult worms in the body-cavity of birds.

Genotype — *Hamulofilaria indica* Chandler, 1924

1 *Hamulofilaria indica* Chandler, 1924 (Fig 12)

Host — Hunting cissa (*Cissa chinensis*); Zoological Gardens, Calcutta. Chandler records a single male specimen, which was found "lying on the mesentery in the vicinity of the liver."

The male measures 7.5 mm in length and 0.215 mm in maximum thickness. The cuticle is "smooth except for a distance of about  $200\mu$  just anterior to the cloaca on the ventral

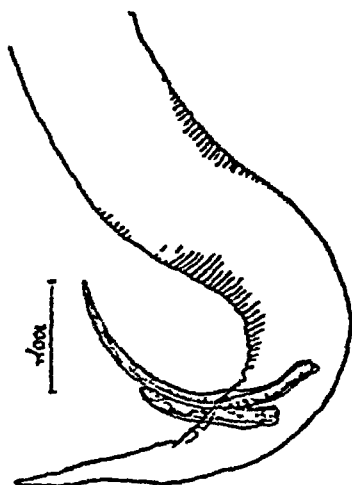


Fig 12 — *Hamulofilaria indica*. Posterior end of male, lateral view (After Chandler, in 'Parasitology')

side, and for a somewhat shorter distance a little farther forward on the dorsal side, where there are conspicuous transverse striations which do not completely encircle the body." The buccal cavity is  $22.5\mu$  deep and about  $15\mu$  in diameter. The oesophagus measures 0.875 mm in length and 0.144 mm in maximum diameter, near its posterior end. The nerve-ring is situated at 0.18 mm, and the excretory pore at 0.31 mm, from the anterior end.

The caudal end is not coiled, but the tail is "bent in the form of a grappling hook," tapers to a sharp point and is 0.2 mm long. Near its tip, on the ventral side, there is a roughened callosity about 0.04 mm long. The longer spicule is "a closed tube up to a point not far from the tip," is slender and measures 0.31 mm in length. The shorter spicule is 0.13 mm long, and "has a pair of conical guards near its tip." The vas deferens is "markedly constricted at its junction with the ejaculatory duct about  $68\mu$  anterior to the cloaca."

## 8 Genus **CHANDLERELLA** Yorke and Maplestone, 1926

Mouth without lip-like structures. Cephalic papillæ unknown. Cuticle smooth. Œsophagus simple, short, stout and club-shaped. Caudal end of male coiled, without alæ. Tail blunt, with inconspicuous papillæ. Spicules equal, short, stout and trough-like. Tail of female short and blunt. Vulva in the Œsophageal region. Female viviparous. Adult worms in the peritoneal cavity or heart of birds. Microfilariae with sheath, occurring in the blood of the host.

Genotype — *Chandlerella bosei* (Chandler, 1924)

### 1 *Chandlerella bosei* (Chandler, 1924) Yorke and Maplestone, 1926 (Fig. 13)

Synonym — *Filaria bosei* Chandler, 1924

**Hosts** — This species was recorded by Chandler from the racket-tailed drongo (*Dissemurus paradiseus*) in the Zoological Gardens, Calcutta. In this instance the worms were found on the peritoneal covering of the axillary air-sac. Pandit, Menon and Iyer (1929) describe specimens from the right ventricle of the heart of a "crow," presumably obtained in the neighbourhood of Madras. Chandler had expressed a doubt whether the female described by him belonged to the same species as the male. Pandit, Menon and Iyer, who had a larger number of specimens, including nine females, consider that Chandler's female worm was of a different species.

The male measures 9–11.5 mm in length and about 0.15 mm in maximum thickness. The female, according to Pandit, Menon and Iyer, has an average length of 24.5 mm and a maximum thickness of 0.33 mm. The Œsophagus, which is not divided into two parts, is about 0.55–0.65 mm long in the male and 0.7 mm in the female. The nerve-ring, in both sexes, is situated at 0.13–0.14 mm from the anterior end.

The tail of the male is 0.14–0.16 mm long, and bears three pairs of small subventral papillæ. The spicules measure 0.07–0.084 mm in length and 0.018–0.021 mm in maximum

width. They are 'approximately alike, short and stout, in the form of curved troughs' (Chandler)

The tail of the female is 0.4 mm long. The vulva is situated at 0.31 mm from the anterior end. The average diameter of the eggs is  $10\mu$ . The embryos, at birth, measure 0.132 mm in length and  $3.8\mu$  in thickness. According to Pandit, Menon and Iyer, the microfilariae found in the peripheral blood of the host are enclosed in a loose sheath and measure, on an average, 0.152 mm in length and  $3.3\mu$  in thickness\*. They are said to show a well-marked nocturnal periodicity.

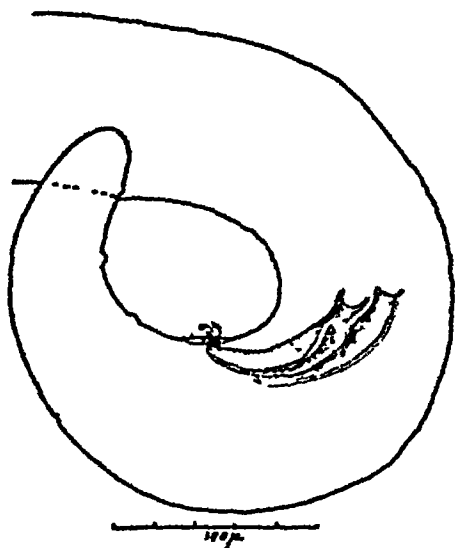


Fig. 13—*Chandlerella borei*. Posterior end of male, lateral view.  
(After Chandler, in 'Parasitology')

In the foregoing description the measurements of the female are taken from Pandit, Menon and Iyer. The measurements given by Chandler are as follows.—Length 28 mm; maximum thickness 0.73 mm; nerve-ring 0.2 mm and excretory pore 0.32 mm from anterior end; tail about 0.2 mm long; vulva 0.45 mm from anterior end. Chandler also gives a detailed description of the female genital organs.

\* Chandler has suggested that either *Microfilaria cephalocauda* or *M. colubroides* (p. 57), both found by him in *Dissemurus paradoxus*, may be the larva of this species. The measurements of both, however, differ considerably from those given by Pandit, Menon and Iyer.

9 Genus **PROTOFILARIA** Chandler, 1929.

Mouth very small, without lip-like structures Body slender Cuticle without striations Head bluntly rounded, without evident papillæ Œsophagus simple, cylindrical. Caudal end of male curled, tail bluntly conical Caudal alæ absent Caudal papillæ apparently absent Spicules unequal, both trough-like, the left spicule longer and with a somewhat spoon-shaped expansion at the tip, the right shorter and with a blunt, slightly recurved tip Posterior end of female truncate, with a terminal dorso-ventral cleft in which the anus is situated Vulva slightly behind the posterior end of the Œsophagus Female viviparous Adult worms parasitic in mammals

Genotype —*Protofilaria furcata* Chandler, 1929.

1. *Protofilaria furcata* Chandler, 1929 (Fig 14)

Host —Ruffed lemur (*Lemur ruber*) (thoracic cavity); Zoological Gardens, Calcutta

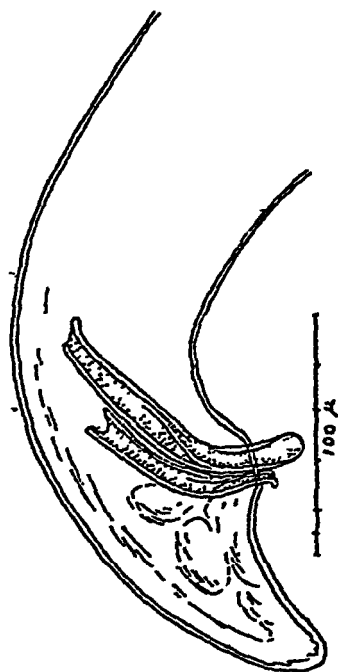


Fig 14 —*Protofilaria furcata* Posterior end of male; lateral view. (After Chandler)

The male measures 13–15 mm in length and 0.15–0.175 mm. in maximum thickness, the female 29–30 mm and 0.325–0.33 mm. respectively The body tapers at each end. The

diameter of the head is about 0.073–0.095 mm. The mouth leads by a minute tube about 0.01 mm long into the oesophagus. The latter is 0.79–0.85 mm long in the male, and about 0.98 mm in the female. The nerve-ring is situated at 0.24–0.26 mm from the anterior end.

The tail of the male is 0.085–0.09 mm long. The left spicule measures 0.115 mm in length, and has "the sides rolled together proximally, but distally expanded into a curved, spoon-shaped structure". Its width is about 0.012–0.013 mm. The right spicule is about 0.07 mm. long, and ends in "a blunt point somewhat resembling the point of a stub pen". According to Chandler "the body substance inside the cuticle at the posterior end of the tail ends in a number of inconspicuous digitations, but there are no papillae".

The vulva is situated at about 1.4 mm from the anterior end. "The uteri and ovaries extend posteriorly and terminate a few hundred micra from the posterior extremity."

#### 10 Genus SETARIA Viborg, 1795

Synonyms.—*Crinon* Chabert, 1782; *Crino* Lamarck, 1801; *Hamularia* Treutler, 1793, of Stiles, 1907; *Tentacularia* Zeder, 1800, of Stiles, 1907; ? *Amularia* Brera, 1810; ? *Anchilocephala* Brera, 1810; ? *Helminthus* Duglison, 1895.

Mouth surrounded by a raised, dorso-ventrally elongate, cuticular or chitinous ring which is notched so as to produce the appearance of two or four forwardly-directed teeth. Body more tapering posteriorly than anteriorly. Cuticle with fine transverse striations. One pair of lateral and usually four pairs of submedian cephalic papillae present. Oesophagus divided into a short, narrow anterior portion and a much longer and stouter posterior portion. Caudal end of male spirally twisted, without alae. About three to five pairs of preanal, a median preanal and three to five pairs of postanal papillae present, and usually, in addition, a pair of small lateral appendages near the tip of the tail. Spicules very unequal and dissimilar, the left long, consisting of a tubular proximal portion and a membranous distal portion, the right short and of irregular shape. Caudal end of female coiled into a loose spiral, the tail conically tapering and curved dorsally, and bearing a pair of lateral appendages near the tip, which is often knobbed or spiny. Vulva in the oesophageal region. Female ovoviviparous. Microfilariae with sheath. Adult worms in the peritoneal cavity of mammals (chiefly ungulates).

Genotype.—*Setaria equina* (Abildgaard, 1789)

## Key to Species

Parasite of Equidæ	<i>equina</i> , p 30
Parasites of ruminants	1
1 Lateral processes of tail of female conical	<i>cervi</i> , p 32
Lateral processes of tail of female bifurcated	<i>marshalli</i> , p 33

1 *Setaria equina* (Abildgaard, 1789) Railhet and Henry, 1911.  
(Figs 15 & 16)

Synonyms — *Gordius equinus* Abildgaard, 1789, *Filaria equi* Gmelin, 1790, *Filaria papillosa* Rudolphi, 1802, *Gordius* (*Filaria*) *papillosus* Oken, 1815, *Filaria equina* Blanchard, 1849, *Filaria papillare* Perroncito, 1882, *Seta equina* Dunglison, 1893, *Filaria oculi* auctt (part), *Filaria palpebralis* auctt (part), ? *Trichina uncinata* Ercolani, 1859, ? *Filaria papillosa oculi* Owles, 1860, ? *Filaria sanguinis equi* Sonsino, 1876; ? *Helminthus gordii* Dunglison, 1895, ? *Microfilaria sanguinis equi* Geddoelst, 1911

*Hosts* — This is a widely-distributed parasite of the horse tribe (horse, donkey, mule and zebra) It occurs mainly in the peritoneal cavity, but occasionally in various other situations, such as the thoracic cavity, lungs, liver, testicles, stomach and intestine There is some doubt as to the identity of the immature specimens of *Setaria* which are not infrequently found in the aqueous humour of the eyes of horses These have sometimes been referred to *S digitata* (i e *S cervi*, see p 32) *S equina* has been recorded by numerous authors from India, Ceylon and Burma

The male measures 48–80 mm in length and 0.4–0.6 mm in maximum thickness, the female 70–120 mm and 0.75–1.1 mm respectively The circumoral ring has four prominences, of which the two lateral are crescentic in outline, the dorsal and ventral truncate The two lateral and four of the submedian cephalic papillæ are usually very prominent There are also two more pairs of smaller submedian papillæ slightly behind the others The œsophagus is about 8–14 mm long, its anterior portion measuring 0.53–1.1 mm and its posterior portion 7.4–13.3 mm The nerve-ring is situated at 0.1–0.28 mm, and the cervical papillæ at 0.33–0.53 mm, from the anterior end

The tail of the male is 0.1–0.15 mm long Its tip is rounded and bears a pair of inconspicuous, papilla-like lateral appendages There are usually eight pairs of caudal papillæ, of which four are preanal and four postanal The left spicule is about 0.63–0.66 mm long (0.32 mm according to Theiler (1923)), and its proximal and distal portions are of about equal length The right spicule measures about 0.14–0.23 mm in length, and is well chitinated and somewhat oblong in lateral view

The tail of the female is 0.38–0.6 mm long, and ends in a knob which is sometimes smooth, sometimes slightly spiny. There is a pair of rounded, papilla-like sublateral appendages at 0.045–0.07 mm. from the tip. The vulva is situated at

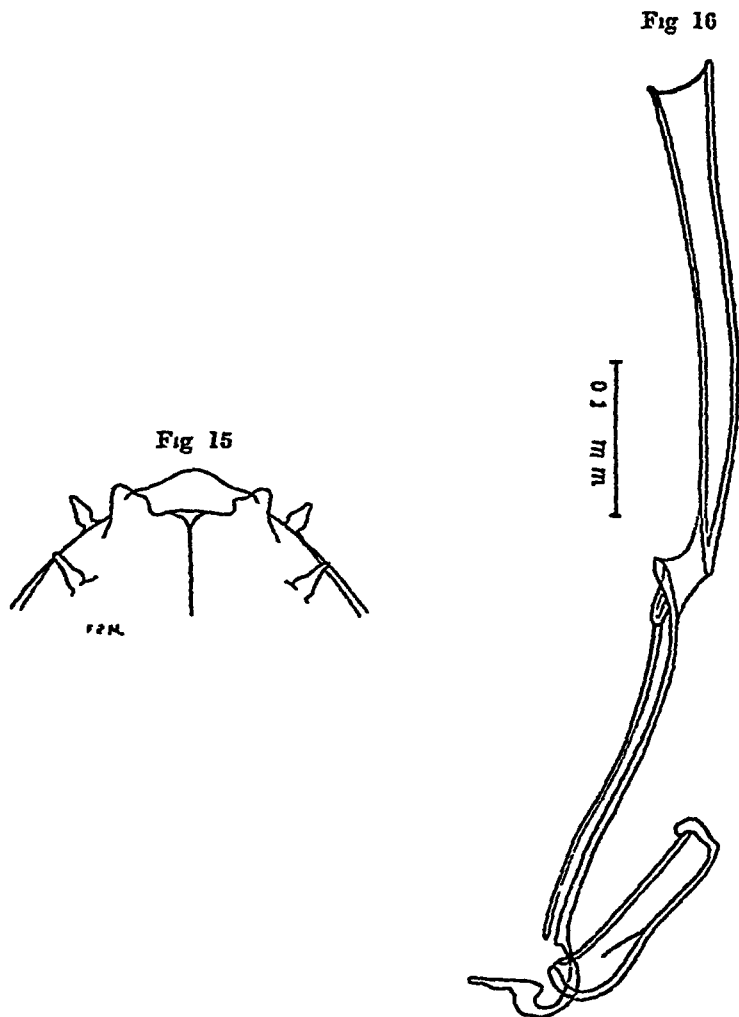


Fig 15—*Setaria equina* Anterior extremity, lateral view  
(From Baylis, after Yorke and Maplestone)

Fig 16—*Setaria equina* Spicules, lateral view  
(After Boulenger, in 'Parasitology')

0.41–0.7 mm from the anterior end. The microfilariae, in the blood of the host, measure about 0.28 mm in length and  $7\mu$  in thickness.

## 2 *Setaria cervi* (Rudolph, 1819) Baylis, 1936 (Figs 17 & 18)

Synonyms \* — *Filaria papillosa* auctt (part), *Filaria oculi* auctt. (part), *Filaria cervi* Rudolph, 1819, *Filaria cervina* Dujardin, 1845, *Filaria terebra* Diesing, 1851 (part); *Filaria bidentata* Moln, 1858, *Filaria cervi elaphi* Moln, 1858; *Filaria labiato papillare* Perroncito, 1882, *Filaria labiato papillosa* Perroncito, 1882; *Filaria labiato-papillosa* Railliet, 1888, *Filaria digitata* v. Linstow, 1906, *Setaria labiato-papillosa* Railliet and Henry, 1911, *Setaria bidentata* Railliet and Henry, 1911, *Setaria digitata* Railliet and Henry, 1911, *Setaria altaica* Rajewsky, 1928, *Setaria cervi* [n sp] Maplestone, 1931, *Setaria buxi* Bhalerao, 1933, ? *Filaria bubali* Rudolph, 1819; ? *Filaria tentaculata* Mehlis, apud Creplin, in Ersch and Gruber, 1846; ? *Filaria bubali (abdominalis)* Moln, 1858, ? *Setaria nudicauda* Ortlepp, 1924

**Hosts** — This species is a widely-distributed parasite of cattle, and occurs also in many other Bovidæ and Cervidæ (Indian and African buffaloes, bison, yak, sheep, antelopes, deer and moose), inhabiting chiefly the peritoneal cavity. It has been recorded from buffaloes and cattle (*Bos indicus*) in various parts of India, and (under the name of *S. digitata*) in Ceylon and Burma

The male measures about 30–60 mm in length and 0.35–0.5 mm. in maximum thickness, the female about 40–120 mm.

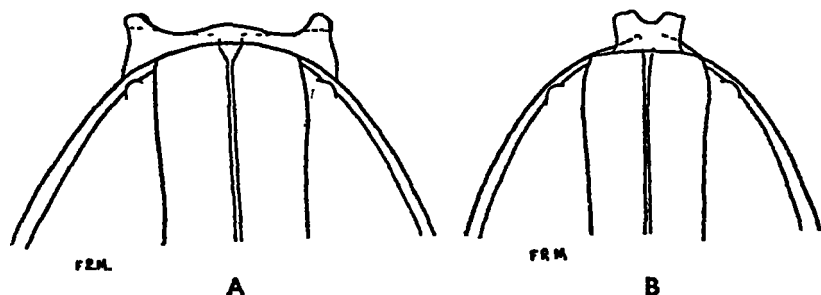


Fig 17 — *Setaria cervi* Anterior end. A, lateral view, B, dorsal view. (After Boulenger, in 'Parasitology')

and 0.5–0.86 mm respectively. The dorsal and ventral processes of the circumoral ring are prominent, but variable in shape. Usually each is notched at the apex, forming two more or less prominent angular points. The lateral processes are less prominent and also variable in shape, but commonly somewhat crescentic. The cephalic papillæ are less prominent than in *S. equina*. The oesophagus is usually about 5–10 mm long, its anterior portion measuring about 0.5–0.9 mm. The nerve-ring is situated at about 0.21–0.33 mm. from the anterior end, and the cervical papillæ at a similar distance behind the nerve-ring.

\* See Baylis, 1936.

The tail of the male is about 0.2–0.24 mm long. The caudal papillae appear to be somewhat variable in number, there being from three to five pairs of preanal or adanal papillae and from three to five pairs of postanal. The usual pair of lateral processes near the tip of the tail is well developed. The left spicule is about 0.26–0.4 mm long, and has a relatively long (nearly 0.2 mm) tubular proximal portion and a distal portion of twisted and complex form. The right spicule is broad, largely membranous and somewhat boat-shaped, and measures about 0.1–0.16 mm in length.

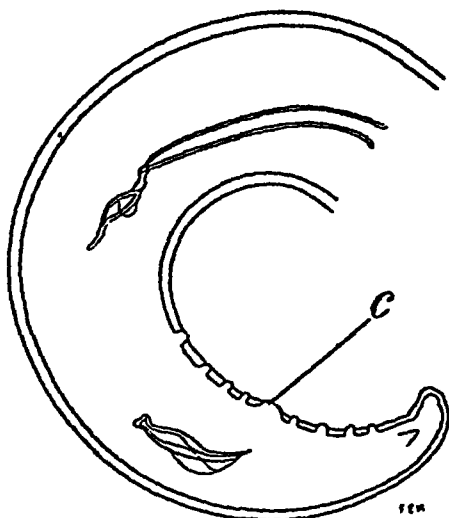


Fig 18—*Setaria cervi*. Posterior end of male, lateral view. c, position of cloacal aperture (After Boulenger, in 'Parasitology')

The tail of the female is about 0.26–0.65 mm. long, and usually ends in a knob which may be smooth or nearly so, or may bear a variable number of large or small spines. The lateral processes are well developed and conical. The vulva is situated at 0.43–0.83 mm from the anterior end.

### 3 *Setaria marshalli* Boulenger, 1921.

Host —“Cattle”, Wassein, Burma.

The following is Boulenger's description, which was based on a single female, in poor condition —

“Head not separated from the rest of the body and appearing truncated anteriorly. The peribuccal ring is elongated in the dorso-ventral direction and is very deeply notched laterally. The lip-like lateral projections . . . are in this species exceptionally prominent and markedly tooth-like, being themselves

indented at their apices, they bear a strong resemblance to the dorsal and ventral teeth which are strong and provided with two cusps. Head papillæ were not observed.

"Female 90 mm in length, with a maximum breadth of about 0.6 mm. The oesophagus has a total length of 9 mm. Anus 0.45 mm from the posterior extremity, the latter is rounded and slightly curved in the dorsal direction. The lateral appendices are bifurcated and situated very close to the posterior extremity of the body. Vulva about 0.6 mm from the anterior extremity."

## 11 Genus *PAPILLOSETARIA* Vevers, 1923.

Resembles *Setaria* in general morphology, but the typical circumoral ring is absent, the paired lateral lips being lined with thickened cuticle, and the cuticle of the body is covered, except at the extremities, with irregularly-scattered bosses. Female viviparous. Adult worms in the peritoneal cavity of chevrotains (*Tragulus*).

Genotype —*Papillosetaria traguli* Vevers, 1923

### 1 *Papillosetaria veveri* Maplestone, 1931. (Figs 19 & 20.)

*Host* —*Tragulus javanicus* ("on the extra-peritoneal surface of the abdominal wall"), Zoological Gardens, Calcutta

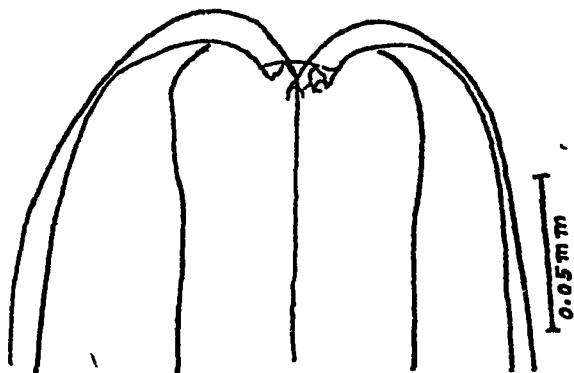


Fig. 19.—*Papillosetaria veveri*. Anterior extremity; dorsal view (After Maplestone)

Maplestone's description of this species is based on one male and one female. The male measures 70 mm in length and 0.24 mm in maximum thickness, the female about 142 mm and 0.46 mm respectively. The cuticle bears irregularly-placed papilliform structures, which extend from about the middle of the oesophagus to the anus in the female, and to about 3 mm from the posterior end in the male. There are two

large, simple, lateral lips, surmounted by thickened cuticle Cephalic papillæ were not observed The two portions of the oesophagus measured 0.58 mm and 1.1 mm in the male, and 0.44 mm and 0.88 mm in the female The nerve-ring, in the male, is situated at 0.297 mm from the anterior end

The caudal end of the male is 'wound in one or two open spiral turns' The tail is pointed and 0.09 mm long There are seven pairs of preanal and three pairs of postanal papillæ The longer spicule measures 0.275 mm in length "Its proximal part consists of a stout curved tube, and the distal half appears to consist of two or more lash-like portions

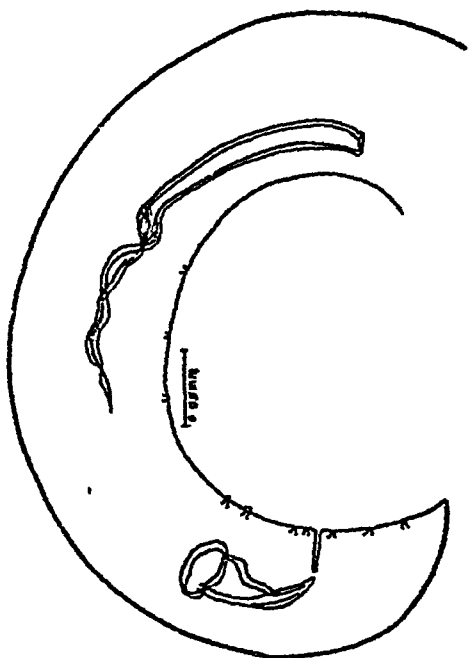


Fig. 20 — *Papillosetaria vevera*. Posterior end of male; lateral view (After Maplestone)

coiled round one another" The shorter spicule is 0.09 mm long, and is shaped much as in *Setaria*.

The tail of the female measures 0.26 mm. in length, is curved dorsally and "ends in a simple point with a pair of large, prominent papillæ on each side of it a short distance anterior to the tip"\* The vulva is situated at 0.535 mm from the anterior end The vagina has a pyriform muscular ovejector. The unpaired trunk of the uterus divides into two branches at a distance of about 1.7 mm from the ovejector

\* This apparently means that there are two pairs of papillæ

## Subfamily DIPLOTRIÆNINÆ Skrjabin, 1916

Head provided laterally with a pair of trilobed epaulette-like or trident-like structures, which may be superficially or more deeply situated Œsophagus typical Spicules of male unequal and dissimilar.

*Key to Genera*

- A pair of trident-like structures present at the sides of the Œsophagus at its anterior end . . . . . DIPLOTRIÆNA, p 36  
 A pair of epaulette-like subcuticular structures present at the sides of the mouth . . . . . HASTOSPICULUM, p 42.

## 1 Genus DIPLOTRIÆNA Railliet and Henry, in Henry and O'Zoux, 1909

Synonyms — *Triplotriæna* Connal, 1912, *Diplotriænia* Maplestone, 1931.

Head with six inconspicuous papillæ (two lateral, four submedian) Mouth small, circular Cuticle smooth At the sides of the anterior end of the Œsophagus a pair of chitnoid "tridents," each with a short forwardly-directed process (which may project at the apex of the head) and three longer posterior processes Œsophagus with a short, slender, anterior muscular portion and a very long, stouter posterior portion Tail of male short, bluntly rounded or truncate A variable number of small, sessile caudal papillæ present Spicules unequal and dissimilar; the left longer and nearly straight, the right shorter and spirally twisted. Common trunk of uterus long Uterine branches at first parallel, then divergent Eggs thick-shelled, containing embryos *in utero* Adult worms in the connective tissue of birds Microfilariae in the blood of the host

Genotype. — *Diplotriæna ozouxi* Railliet and Henry, 1909\*.

*Key to Species*

- |  |    |                            |
|--|----|----------------------------|
| Left spicule of male at least 1 mm long . . .                      | 1. |                            |
| Left spicule of male less than 1 mm long . . .                     | 3  |                            |
| 1 Male apparently without caudal papillæ . . .                     |    | <i>nagpurensis</i> , p 42. |
| Male with several pairs of preanal and post-anal papillæ . . . . . | 2  |                            |
| 2 Preanal papillæ three or four pairs . . .                        |    | <i>tricuspis</i> , p 37    |
| Preanal papillæ two pairs . . . . .                                |    | <i>gracilis</i> , p 39     |
| 3 Right spicule of male less than 0.4 mm long . . .                |    | <i>bhamoensis</i> , p 38   |
| Right spicule of male more than 0.4 mm long . . .                  | 4  |                            |
| 4 Preanal papillæ of male four pairs . . . . .                     |    | <i>dubia</i> , p 40        |
| Preanal papillæ of male two pairs . . . . .                        |    | <i>urocissæ</i> , p 41     |

\* The name *Diplotriæna* was originally proposed by Railliet and Henry as a subgenus of *Filaria*, with *ozouxi* as type-species Seurat (1915, a) appears to have given it generic rank, using it in combination with *tricuspis* Skrjabin (1916) also did so, quoting *tricuspis* as genotype

1. *Diplotrisaena tricusps* (Fedchenko, 1874) Seurat, 1915.  
(Figs 21 & 22)

Synonyms.—*Filaria tricusps* Fedchenko, 1874, *Aprocta tricusps* v. Linstow, 1905; *Diplotrisaena acridotheres* Karve, 1934; ? *Filaria ninni* Stossich, 1891

*Hosts*—This species has been recorded from crows and from a large number of other birds, belonging to various families (mainly Passeriformes), in Europe, Asia, Africa and America. In India it has been recorded from Blanford's laughing-thrush (*Trochalopteron jerdoni meridionale*) (Baylis and Daubney, 1922), and from the Indian mynah (*Acridotheres ginginianus*) in the Aligarh district, United Provinces (Mazhar, 1933)

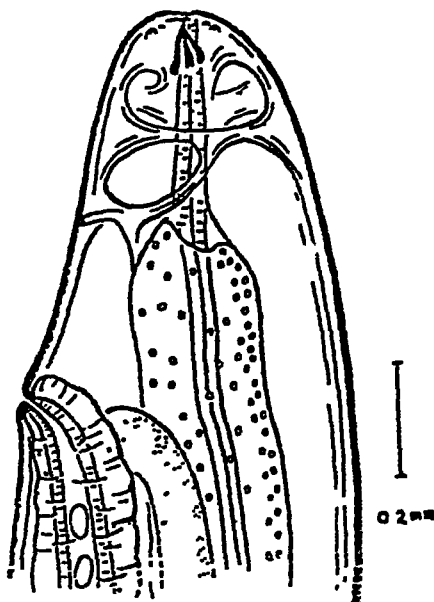


Fig 21—*Diplotrisaena tricusps* Anterior end of female; lateral view.  
(After Li, in 'Parasitology')

*D. acridotheres* Karve, 1934, which appears to be identical with *D. tricusps*, is recorded from *Acridotheres tristis* at Nagpur, Central Provinces

The male measures 36–75 mm in length and about 0.6–0.7 mm in maximum thickness, the female about 40–200 mm. and 0.6–1.28 mm respectively. The "tridents" are about 0.09–0.24 mm long. The oesophagus has a total length of about 4.5–11 mm, its anterior portion measuring about 0.2–0.6 mm. The posterior portion widens suddenly to about three times the width of the anterior portion. The nerve-ring is situated at 0.17–0.28 mm. from the anterior end, and

the excretory pore at approximately the same level (about half-way between the mouth and vulva in the female)

The tail of the male is about 0.13 mm long, and has a truncate termination. There is some lateral expansion in the region of the cloacal aperture. From nine to eleven pairs of caudal papillæ are present, six of which form subventral series, beginning with three or four in front of the cloacal aperture and converging posteriorly. In addition to these subventral papillæ, from three to five pairs are situated laterally or subterminally on the expanded portion of the tail. The left spicule is straight and measures about 1.25 mm in length. The right spicule is 0.55–0.92 mm long, and is spirally twisted in about  $1\frac{1}{2}$  turns.

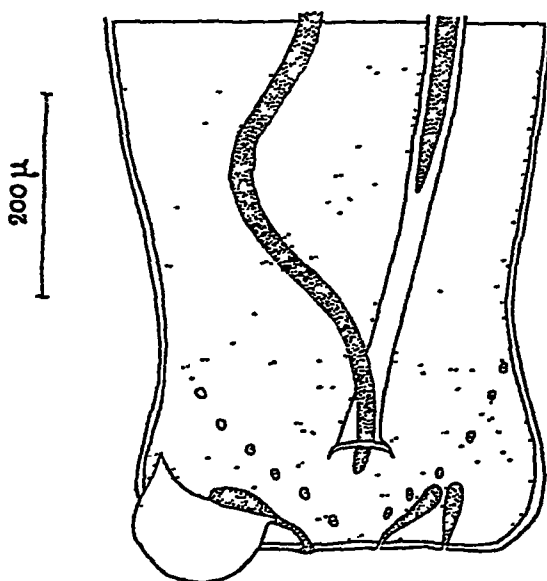


Fig. 22 — *Diplotriæna tricusps*. Posterior end of male, ventral view. (After Seurat.)

The anus of the female is subterminal. The vulva is situated at about 0.43–0.8 mm from the anterior end. The vagina has thick, muscular walls, and is about 4 mm. long. The eggs measure, *in utero*, about  $0.045\text{--}0.06 \times 0.03\text{--}0.04$  mm. According to Seurat, they hatch in the blood of the host.

## 2 *Diplotriæna bhamoensis* (Parona, 1889).

Synonyms.—*Filaria bhamoensis* Parona, 1889; *Diplotriæna chamoensis* Yorke and Maplestone, 1926.

*Host* :—This species is recorded by Parona from *Æthiopsar [Acridotheres] albocinctus* at Bhamò, Burma. The worms

occurred in the body-cavity, forming dense knots in the mesentery and on the outside of the liver and testes

The worm is so poorly described by Parona that it is impossible to determine whether it is an independent species or should be regarded as a synonym of *D. tricuspis* (as the host suggests) or of some other form. From the description and figure of the "chitinous armature" of the head it seems probable that it is a *Diplotriæna*, as has been suggested by Henry and O'Zoux (1909) and by Yorke and Maplestone (1926) (*D. chamoensis*). In several of the measurements given by Parona the decimal point appears to have been misplaced. According to his description the male measures 35-37 mm in length, the female 123-150 mm. The mouth is terminal, and has a "chitinous armature" consisting of three "loops" (*anse*) joined together anteriorly "in the median line" and measuring 0.011 mm in length and 0.014 mm in width [? 0.11 and 0.14 mm].

The tail of the male is said to be not spirally coiled, not mucronate, and without alæ. The spicules are unequal, one curved and measuring 0.75 mm in length, the other "serpentine," stouter, and 0.035 [? 0.35] mm long.

The tail of the female is rounded. The vulva is situated at 0.5 mm from the anterior end. The "oviduct" [? vagina] is very long and sinuous. The eggs are oval, with smooth, transparent shells measuring  $0.056 \times 0.028$  mm.

### 3 *Diplotriæna graculi* (Maplestone, 1931).

Synonym —*Diplotriæna graculi*, Maplestone, 1931.

Host —Red-billed chough (*Pyrrhocorax pyrrhocorax* [= *Graculus eremita*]) (under peritoneum), Zoological Gardens, Calcutta.

The male measures 27.5-32 mm in length and 0.594 mm in maximum thickness, the female 70-108 mm and 0.326-0.455 mm respectively. The cuticle is apparently unstriated. The head is rounded in lateral view, square in dorso-ventral view. Its lateral diameter, in the male, is 0.16 mm. There are four large submedian cephalic papillæ. The tridents are somewhat irregular in shape, and show considerable variation in the length of their branches. Their total length is 0.18-0.208 mm. The oesophagus, in the male, is 1.2 mm long, its anterior portion measuring 0.45 mm. The nerve-ring is situated a little in front of the junction of the two portions.

The caudal end of the male appears bluntly rounded in both lateral and dorso-ventral views. There are two pairs of pre-anal and one pair of postanal papillæ, all of which are subventral. In addition the ventral surface of the tail, near the tip,

bears a number of "small round bosses," which may also be papillæ. The left spicule\* is straight and measures 1.565 mm in length. The right spicule is 0.634 mm long. Proximally it is straight and tubular, but its distal portion is spirally twisted in five or six turns. "Its broad membranous ala gives it an appearance similar to an auger."

The vulva is slightly prominent, and is situated at 0.49–0.59 mm from the anterior end. The vagina has a length of 0.89–1.3 mm.

#### 4 *Diplotriazæna dubia* (Maplestone, 1931) (Fig 23)

Synonym :—*Diplotriazæna dubia* Maplestone, 1931

*Host* —Red-billed chough (*Pyrrhocorax pyrrhocorax* [= *Graculus eremita*]), Zoological Gardens, Calcutta

The description of this species is based on a single male specimen, which is said to be 8.55 mm long † and to have

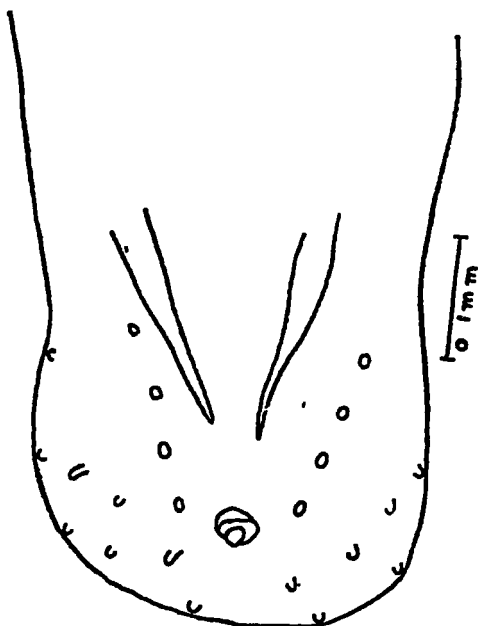


Fig 23 —*Diplotriazæna dubia* Posterior end of male, ventral view (After Maplestone)

a thickness of 0.693 mm. The anterior end is indistinguishable from that of *D. graculi*. The oesophagus is 1.5 mm long.

The caudal end is rounded in lateral view, but truncate and slightly expanded laterally in ventral view. The

\* The left and right spicules appear to have been reversed in Maplestone's description. His figures, however, agree with the account here given.

† Elsewhere, however, it is said to be about twice as long as the male of *D. graculi*—i.e. at least 55 mm.

postcloacal portion of the ventral surface is covered with rather pointed papilla-like prominences, and there are four precloacal papillæ on each side" The figure given shows (in addition to four pairs of subventral preanal papillæ, forming two rows which diverge anteriorly) what appear to be six papillæ on the left side and eight on the right. Some of these are subventral and some lateral or sublateral, and several of the more anterior are preanal. The left spicule (referred to as the right in the description) is straight and 0.812 mm long. The right ("left") spicule measures 0.594 mm, and has a "broad double curve".

5 *Diplotrizæna urocissæ* (Maplestone, 1931) (Fig 24)

Synonym — *Diplotrizænia urocissæ* Maplestone, 1931.

Host — Yellow-billed blue magpie (*Urocissa flavirostris*) ("in the sub-peritoneal tissue of the body-cavity"); Zoological Gardens, Calcutta.

The description is based on a single male specimen. This

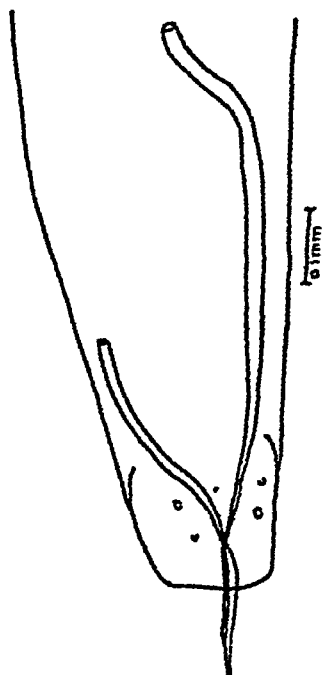


Fig 24 — *Diplotrizæna urocissæ*. Posterior end of male; ventral view. (After Maplestone)

was 18.2 mm long and 0.515 mm. thick. The head appears rounded in lateral view, concave in front in dorso-ventral view, with the anterior ends of the tridents projecting as sharp points. The length of the tridents is 0.148 mm. The

œsophagus is 2.457 mm long, its anterior portion measuring 0.257 mm and its posterior portion 2.2 mm

The caudal end is truncate in ventral view. There are two pairs of subventral preanal papillæ. No other papillæ are mentioned or figured. The left spicule (referred to as the right in the description) measures 0.713 mm in length. For the greater part of its length it is straight, but near its root it is somewhat curved. The right ("left") spicule is 0.495 mm long, the whole forming an open S-shaped curve.

## 6 *Diplotrixena nagpurensis* Karve, 1934

*Host* —Mynah (*Acridotheres tristis*) (body-cavity), Nagpur, Central Provinces

The description is based on a single male specimen, which measured 33.95 mm in length and about 0.59 mm in maximum thickness. The head appears concave in front in dorso-ventral view. The tridents are 0.165 mm long, and have truncate or concave anterior ends which project beyond the cuticle. The anterior portion of the œsophagus is about 0.27 mm long, the posterior portion about 7.2 mm. The nerve-ring is situated at 0.2 mm from the anterior extremity.

The caudal end is rounded in lateral view and truncate in ventral view. Its ventral cuticle has a granular appearance. No caudal papillæ were seen. The left spicule measures 2.1 mm in length, the right spicule 0.5 mm. The latter is spirally twisted.

## 2 Genus *HASTOSPICULUM* Skrjabin, 1923

Mouth situated in a dorso-ventrally elongate depression, each lateral wall of which is formed of thickened cuticle and bears a small, forwardly-directed tooth-like process. On either side of the oral depression there is typically an "epaulette-like" subcuticular structure. A pair of lateral organs and usually four pairs of submedian cephalic papillæ present. Œsophagus composed of a short and narrow anterior muscular portion and a long and wide posterior glandular portion. Male with short caudal alæ forming a bursa-like structure. A variable number (up to eight pairs) of caudal papillæ present, most of which have long peduncles. Spicules unequal, the left much longer than the right. Vulva in the œsophageal region. Female oviparous, the eggs containing embryos when laid. Adults under the serous membranes or in the connective tissue of reptiles.

*Genotype* —*Hastospiculum varani* Skrjabin, 1923\*

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\* If, as appears very probable, this species is identical with *H. macrophallos* (Parona, 1889), the genotype should take the latter name.

1 *Hastospiculum macrophallos* (Parona, 1889) Baylis, 1930  
(Figs 25 & 26)

Synonyms — *Filaria macrophallos* Parona, 1889, *Hastospiculum spinigerum* Chandler, 1929; ? *Filaria varani* Baylis and Daubney, 1922, ? *Hastospiculum varani* Skrjabin, 1923

*Hosts* — Parona (1889) recorded *Filaria macrophallos* from the abdominal muscles of *Varanus* [*Hydrosaurus*] *salvator* in Burma (mountains of Catein Cauri, east of Bhamò). Baylis and Daubney (1922) record it from *Varanus salvator*, *V. flarescens* and *V. nebulosus*, probably all in the Zoological Gardens, Calcutta. The collector's labels indicated the lungs, thoracic cavity and "intestines" (probably abdominal cavity) as the habitat of the worms. Chandler (1929) records *H. spinigerum* from under the peritoneum of *Varanus flarescens* in the Zoological Gardens, Calcutta. Maplestone (1931) also obtained material from the same host and locality, and supports the present writer's (1930, c) view that *H. spinigerum* is identical with *H. macrophallos*. Chitwood (1922, a), on the other hand, gives a description of *H. spinigerum* which is stated to have been "made from a restudy of the type specimens," and treats it as distinct from *H. macrophallos*, of which, however, he does not appear to have seen specimens. Skrjabin (1923) described *H. varani* as a new species, based on males only, from *Varanus griseus* (from Russian Turkestan, in captivity in Russia). Sandground (1933) found specimens, from *Varanus salvator* in Annam, intermediate in some respects between *H. macrophallos* (as described by Baylis, 1930) and *H. varani* Skrjabin, and expresses the opinion that the latter "may have to be placed in the synonymy of the former species." This question the writer still feels it wise to leave open, though there seems to be little room for doubt that *H. spinigerum* and *H. macrophallos* are identical. The *Filaria varani* of Baylis and Daubney (1922) was based on a single male specimen, which seems very probably to have been an abnormal specimen of *H. macrophallos*.

The following description is derived from the various accounts referred to above. Complete specimens are seldom obtained, and males appear to be comparatively rare. The male measures about 80–100 mm in length and 0.41–0.7 mm in maximum thickness, the female up to about 250 mm and 1.4–2 mm respectively. The cuticle is transversely striated, some of the striations being very prominent, especially in the female. The mouth is small and circular, and is situated in a roughly oblong depression whose longer axis is dorso-ventral. The lateral borders of the depression are formed by somewhat thickened plates of cuticular material, from the middle of each of which springs a small, but prominent, forwardly-directed tooth-like process, which is somewhat

square-ended when seen in profile. Below each tooth there appear to be three finger-like processes which converge towards its base. Dorsally and ventrally to the mouth-depression there are delicate, flat, cuticular plates. Laterally to the lateral walls of the depression there are two "epaulette-like" subcuticular structures, apparently of a parenchymatous nature. The lateral edge of each "epaulette" is produced, at the beginning of the lateral field of the body, into a process on which is situated a "lateral organ". This is rather pore-like than papilla-like. Near the angles of the "epaulettes" there are two pairs of inconspicuous submedian papillæ with very minute terminations, and within the angles there are four very faintly visible structures which may possibly also be papillæ. There would thus be eight submedian papillæ.

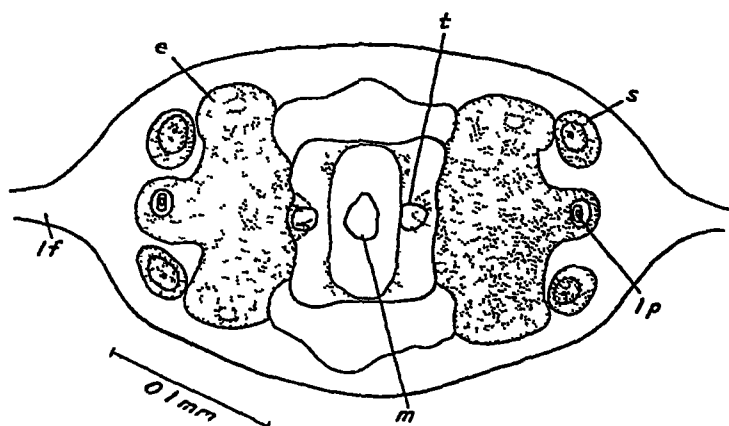


Fig 25 — *Hastospiculum macrophallos*. Anterior extremity of female, viewed en face. *e*, "epaulette-like structure", *lf*, lateral field, *lp*, lateral papilla; *m*, mouth; *s*, submedian papilla, *t*, tooth (After Baylis)

The anterior portion of the œsophagus measures, in the female, 0.55–0.6 mm in length, the posterior portion about 30 mm. At its commencement the latter occupies the whole width of the body-cavity. In the male of *F. varani* Baylis and Daubney the anterior portion of the œsophagus measured 0.35 mm in length, the posterior portion 16 mm. The nerve-ring is situated somewhat behind the middle of the anterior portion.

The caudal end of the male is bluntly rounded, and is provided with alæ which begin only a short distance in front of the cloacal aperture and are continuous round the posterior extremity, thus forming a bursa-like structure. The caudal papillæ appear to be rather variable in number and arrangement. Parona found seven pairs, the present writer (1930, c)

eight pairs. Skrjabin also found eight pairs in *H. varani*, while Chitwood describes, for *H. spinigerum*, eight papillæ on the left and seven on the right side. In Chitwood's figure all the papillæ appear to be laterally situated, whereas Parona and Baylis found three pairs, in front of the cloacal aperture, placed subventrally. A similar arrangement was also found in *Filaria varani* by Baylis and Daubney, but there were only two, and not three, subventral pairs. The left spicule, according to various descriptions, varies between 2 mm. and 4.45 mm. in length, the right between 0.42 mm. and 0.51 mm. (Skrjabin gives 0.66 mm. for the shorter spicule in *H. varani*, while in *Filaria varani* Baylis and Daubney, in which only one spicule was found, this was 0.6 mm. long). Both spicules are alate, and have pointed and slightly hooked tips.

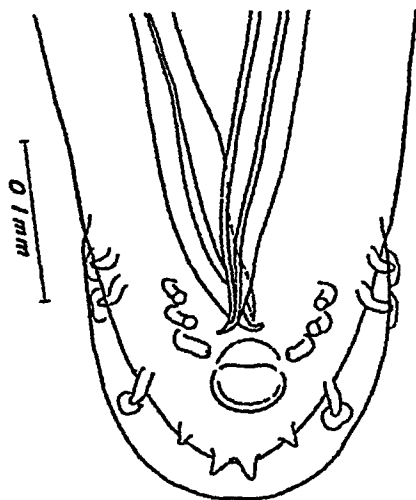


Fig. 26 — *Hastospiculum macrophallos*. Posterior end of male, ventral view (After Baylis).

The tail of the female is bluntly rounded, and bears a pair of papillæ at its extremity. The anus is subterminal. The vulva is situated at 0.85–1.15 mm. from the anterior extremity. The muscular vagina may run straight back, or may be much convoluted. The eggs are of a very characteristic shape, somewhat resembling a barrel, with an annular thickening near each pole. They measure 0.05–0.052 × 0.03–0.034 mm., have thick shells, and contain coiled embryos when ready for laying.

## Subfamily APROCTINÆ Yorke and Maplestone, 1926.

Head without epaulette-like or trident-like structures  
 Œsophagus frequently atypical (without obvious division into anterior and posterior portions) Anus frequently non-functional, sometimes absent Tail of male without alæ. Caudal papillæ absent or few and inconspicuous Spicules short, usually equal or subequal, and similar

### Key to Genera

- |   |                    |
|---|--------------------|
| Spicules of male short, subequal and conical,<br>vulva near middle of body                | CONISPICULUM, p 46 |
| Spicules of male unequal, broad and trough-like,<br>vulva near posterior end of œsophagus | PARAFROCTA, p 49   |

### 1 Genus **CONISPICULUM** Pandit, Pandit and Iyer, 1929

Mouth without lip-like structures Cuticle with fine transverse striations Cephalic papillæ unknown Œsophagus muscular throughout, not divided into two portions, but conical anteriorly and cylindrical posteriorly Caudal end of male spirally coiled, without alæ A few pairs of small postanal papillæ present Spicules subequal, similar, short and conical Tail of female blunt Vulva near the middle of the body. Vagina long Uterine branches parallel at their origin Female viviparous or ovoviviparous Adults in the connective tissue of reptiles Microfilariae with sheath, occurring in the blood of the host

Genotype —*Conispiculum flavescens* (Castellani and Willey, 1905)

### 1 **Conispiculum flavescens** (Castellani and Willey, 1905)

Synonyms —*Filaria flavescens* Castellani and Willey, 1905,  
*Conispiculum guindiensis* Pandit, Pandit and Iyer, 1929.

*Host* —The "bloodsucker" (*Galotes versicolor*) (in the connective tissue, chiefly in the mesentery, pelvic region and along the trachea, also in the lungs), Colombo, Ceylon (Castellani and Willey), Guindy, Madras (Pandit, Pandit and Iyer)

Castellani and Willey (1905), in recording the occurrence of microfilariae in the blood of this lizard, mentioned the finding of two adult worms in the mesentery, and proposed the name *Filaria flavescens* for them They gave no description,

beyond stating that the worms were characterized by the bright lemon-yellow colour of the intestine. The specimens were forwarded to v. Linstow, who (1906, d) gave a very brief description of them. Pandit, Pandit and Iyer (1929, a) described, under the name of *Conispiculum guindiensis*, a Filarid from the same host. They believed it to be distinct from *F. flavescens*, but, as will be seen, they were misled by v. Linstow's description. Through the courtesy of the Director of the Colombo Museum, the writer has been able to examine the type male and female of *F. flavescens*. Though both specimens are in poor condition and damaged, it has been possible to establish the fact that v. Linstow's description was, in at least one important point, erroneous, and there is little doubt that *C. guindiensis* is the same species.

According to v. Linstow the male measures 19 mm in length and 0.33 mm in maximum thickness, the female 56 mm and 0.65 mm respectively. Pandit, Pandit and Iyer give the average length of the male as "0.28" [? 28] mm, and its thickness as 0.3 mm in the middle of the body, while for the female they give 95 mm as the average length and 0.73 mm as the thickness in the middle. The type female is incomplete. The portion remaining (now in two pieces) is of about the length given by v. Linstow. Its maximum thickness (the thickest portion being considerably in front of the middle) is about 0.7 mm, while that of the male is about 0.32 mm. The Indian authors state that the cuticle is smooth, with fine longitudinal striations. In the type-specimens there are exceedingly fine and faint transverse striations. The head is bluntly rounded. According to v. Linstow the mouth is without lips, according to the Indian authors it is "simple, with two inconspicuous lateral (?) obtuse flaps". In the male type the mouth appears to be quite terminal and simple. In the female type, however, it appears to lie in a very slight depression. No cephalic papillæ have been made out. The oesophagus, according to Pandit, Pandit and Iyer, has an average length of 1.04 mm in the male and 1.23 mm in the female. In the type male it measures about 1.1 mm, and in the type female 1.5 mm. The oesophagus is muscular throughout, and is of a peculiar shape, its anterior end being conical (rather than cylindrical, as stated by the Indian authors), and its longer posterior portion cylindrical (rather than "bulbous"). There is no sharp distinction between the two portions, the anterior widening gradually to the diameter of the posterior. The intestine is very narrow at its junction with the oesophagus, but widens rapidly. The nerve-ring is situated at about 0.2 mm from the anterior end in the male, and slightly more in the female.

The caudal end of the male is spirally coiled, and the tail rather sharply curved ventrally. The latter is about 0.2 mm long, and has a blunt tip with a dorso-ventral indentation, giving rise to the appearance of "two clear, rounded, fairly big bosses," as described by the Indian authors. There are no alæ. The cloacal aperture is prominent. v Linstow mentions "five very small post-anal papillæ," while the Indian authors say that there are usually seven pairs, "the papillæ diminishing in size from the anus downwards." In the type male not more than five pairs of postanal papillæ could be made out, and these were very small. Two pairs were near the cloacal aperture, two near the tip of the tail and one at about its middle. There appeared, however, also to be at least one pair of small preanal papillæ. The spicules are relatively very short and conical, with broad, funnel-shaped roots. According to v Linstow they are 0.16 mm long. According to the Indian authors, the two spicules average respectively 0.14 mm and 0.132 mm in length. In the type male the left spicule is about 0.15 mm long, and has a smooth, sharp, oblique point, like the tip of a hypodermic needle. The right spicule is about 0.14 mm long, and has a blunt tip. This spicule has a few transverse corrugations on its dorsal surface near the tip. There appears to be an irregularly-shaped accessory piece, or cuticular thickening of the dorsal wall of the cloaca, nearly as long as the spicules. This is not mentioned by the previous describers.

The tail of the female, according to Pandit, Pandit and Iyer, has an average length of 0.41 mm, and is blunt. The anus is prominent. (According to v Linstow there is no anus. The posterior end of the type female is now missing.) The vulva was erroneously stated by v Linstow to be situated at 1.97 mm from the anterior end. In the type female, as in *G. gundiensis*, it is situated somewhere near the middle of the body. The vagina is long, narrow and muscular. It begins with a small ovejector, and at first runs forward for about 0.3 mm from the vulva, then doubles back and runs posteriorly to a point about 0.55 mm behind the vulva. Here it forms a loop which runs almost completely round the body-cavity and forward again to the level of the vulva, where it gives off two parallel uterine branches. These run anteriorly from their origin, but appear to double back again at a point about 3.5 mm in front of the vulva. According to the Indian authors the vulva is prominent, but in Castellani and Willey's type this is not so. The uterine branches and ovarian tubes are exceedingly long and much convoluted, and it was not possible to follow out their course in detail. The anterior limit of the ovarian tubes is about 0.5 mm.

behind the oesophagus v Lanstow calls the worm "ovoviviparous," though the uterus, in the type female, contains numerous free embryos Pandit, Pandit and Iyer also regard the worm as "ovoviviparous," and state that they have observed both free embryos and eggs being deposited The microfilariae, as found in the blood of the host by these authors, have a loose sheath and measure 0.086–0.114 mm in length and 5–10 $\mu$  in thickness

Pandit, Pandit and Iyer (1929, b) have shown experimentally that *Gulex fatigans* can act as a vector for *G. guindensis*, and have described the development of the larvæ in it, which they find to take 11–15 days, and to involve stages similar to those of *Wuchereria bancrofti*

## 2 Genus PARAPROCTA Maplestone, 1931

Mouth without lip-like structures Cephalic papillæ unknown Cuticle smooth Oesophagus short, not divided into two portions Caudal end of male without alæ; tail curved, bluntly rounded Caudal papillæ absent or very inconspicuous Spicules unequal, but both broad and trough-like Anus absent in adult female Vulva near the posterior end of the oesophagus Female viviparous Adult worms in the body-cavity of birds

Genotype —*Paraprocta brevicauda* (Chandler, 1924)

### 1 *Paraprocta brevicauda* (Chandler, 1924) Maplestone, 1931. (Fig. 27)

Synonym —*Filaria brevicauda* Chandler, 1924

*Hosts* —This species was originally described by Chandler from the racket-tailed drongo (*Dissemurus paradiseus*) and the hunting cissa (*Cissa chinensis*) Maplestone (1931) has also recorded it from *Oriolus indicus* (probably *O. chinensis diffusus*), *Goracias benghalensis indica*, *Arborophila atrogularis*, *Dendrocitta rufa*, *Gopsychus saularis* and *Polyplectron bicalcaratum* All the above-mentioned hosts were birds that had died in the Zoological Gardens, Calcutta According to Chandler, the worms occur in or on the liver of the hosts Chandler expressed a doubt whether the single female found by him belonged to the same species as the males, but Maplestone, who has examined a large amount of material and given a new description, considers that its determination was correct

The male measures 7.5–10.5 mm in length and 0.16–0.2 mm in maximum thickness, the female 16–18 mm and 0.35–0.45 mm respectively The body is bluntly rounded at each

end The diameter of the head is 0.092–0.095 mm in the male and 0.128 mm in the female Neither Chandler nor Maplestone was able to observe any cephalic papillæ The oesophagus is 0.4–0.6 mm long. Its maximum thickness, in the female, is about 0.032 mm The nerve-ring is situated at 0.146–0.192 mm, and the excretory pore at 0.28–0.52 mm, from the anterior end

The tail of the male is short (0.06–0.065 mm) According to Chandler, there are two pairs of inconspicuous papillæ, one pair preanal and one postanal Maplestone was unable to observe these, but says that "an appearance simulating papillæ in these positions is caused by an optical section of the body pulp, which bulges round the cloacal aperture" Chandler gives the lengths of the spicules as 0.106 mm and

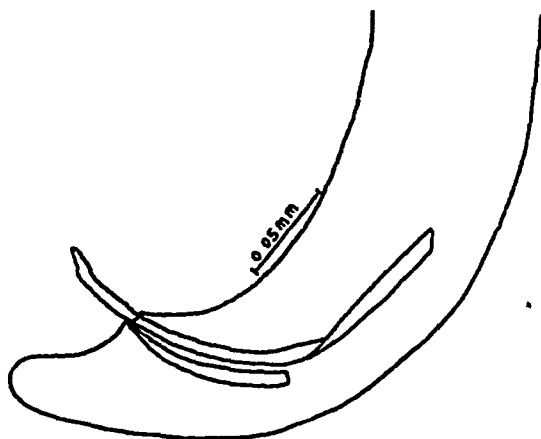


Fig 27.—*Paraprocta brevicauda* Posterior end of male; lateral view. (After Maplestone)

0.065 mm Maplestone, however, finds them to be 0.18–0.2 mm and 0.06–0.07 mm respectively, and suggests that part of the longer spicule had been broken off in Chandler's material Both spicules are broad and trough-like

The tail of the female is bluntly rounded and 0.16 mm long According to Maplestone, the anus is completely covered by the cuticle In young specimens it is connected with the intestine by a "cord," but this connection disappears in older individuals The vulva is inconspicuous According to Chandler, it is situated at 0.38 mm from the anterior end Maplestone, however, finds it at 1.1–1.2 mm, and suggests that Chandler mistook for it an anterior portion of the uterus.

For the possible larval form of this species see *Microfilaria cephalocauda* and *M. colubrordes* (p 57), see also the footnote to *Chandlerella bosei* (p 27)

FILARIIDÆ OF UNCERTAIN POSITION  
("Filaria," sens lat)

1 *Filaria* "abbreviata" Rudolphi, 1819

Synonyms — *Filaria turdorum*, *F. motacillarum*, *F. motacillæ* Rudolphi, 1819, *Filaria myotheræ chrysopygæ* Molin, 1858

*Hosts* — Rudolphi originally recorded *Filaria abbreviata* from the orbit of *Motacilla stapanina* in the Vienna Museum. From this host he had seen only females, but he appears to have seen other specimens, including a male, which he thought might be of the same species, from the eyes and nostrils of *Falco naevius* Molin (1858) and other authors have attributed to *F. abbreviata* worms from a number of Passeriform birds in Europe and Brazil, the locations including the orbit, body-cavity and subperitoneal connective tissue. Baylis and Daubney (1922) tentatively refer to *F. abbreviata* two female Filariids from the orbit of *Saxicola* sp in India (probably in the Zoological Gardens, Calcutta).

Rudolphi's description of his original specimens is extremely brief. Of the females from *Motacilla stapanina* he says that they were 8-9 lines ( $\frac{3}{4}$ - $\frac{7}{8}$  in) long, with a stoutish, cylindrical body, tapering and blunt at the head end, and with a rounded tail. The mouth was circular. Concerning the male from *Falco naevius*, he says that the tail formed a single spiral coil and had a short, pointed, terminal spike. There was a curved spicule (?) (*filum genitale*). Alæ were scarcely visible. A slightly fuller description of what he believed to be Rudolphi's species was given by Molin, who gives the length of the male as  $\frac{1}{2}$ -1 inch, and that of the female as  $\frac{1}{2}$ - $\frac{1}{2}$  inches. The thickness was  $\frac{1}{4}$ - $\frac{1}{2}$  line ( $\frac{1}{48}$ - $\frac{1}{24}$  in). The Latin description includes mention of "*faux dentibus sex, ternatim in latus superum et inferum convergentibus armata*". The body is said to be armed with longitudinal rows of deciduous spines. The "penis" [? spicule] is spirally twisted. Influenced, presumably, by Molin's reference to six teeth, converging in two groups of three, Henry and O'Zoux (1909) and Yorke and Maplestone (1926) have referred *F. abbreviata* to *Diplotrixena*. It may be that Molin was actually dealing with a *Diplotrixena*, though this seems by no means certain. Still less is it certain that Molin's species was the same as Rudolphi's. The specimens recorded by Baylis and Daubney are described as follows. —

"The larger specimen is about 24 mm long and 0.57 mm in thickness. The anterior end of the body is abruptly attenuated and sharply truncated. The cuticle is smooth, and we are unable to detect the longitudinal rows of deciduous spines to which Molin refers. The mouth opens into a small

buccal cavity which is about 0.032 mm deep and 0.02 mm. in diameter. We are unable to distinguish any teeth at the base of the buccal cavity, but its wall is thrown into folds presenting an appearance which might easily have been mistaken for teeth. The œsophagus consists of two parts. The anterior portion is 0.25 mm in length and distinctly more slender than the posterior portion. The latter measures 0.75 mm in length and about 0.12 mm in thickness. It is very slightly enlarged posteriorly. The nerve-ring surrounds the œsophagus at about 0.13 mm from the anterior end, while the excretory pore opens at about 0.2 mm from the head. The posterior extremity is rounded and not noticeably attenuated. The anus is small and subterminal. The vulva is situated close to the head, at about 0.45 mm from the anterior end. There is a short transverse vagina, directed slightly backwards, from which two ovejectors are given off. The uteri and ovaries are both posterior, but a forwardly-directed loop in the ovejector of one of them indicates that this represents an anterior uterus. The eggs in the uterus measure about  $0.024 \times 0.017$  mm, and are in various stages of segmentation."

## 2 "*Filaria*" *tuberosa* v Linstow, 1906

Synonym —*Filaria mansonii* Castellani and Willey, 1904 (*nec* Cobbold, 1879, *nec* Huber, 1896)

*Host* —Brahminy lizard (*Mabuya carinata*); Colombo, Ceylon. (Adult females in musculature of body-wall, microfilariae in blood.)

A very brief description of this form is given by Castellani and Willey (1904). Some of the original specimens (apparently not now available in the Colombo Museum) were re-examined by v Linstow (1906, *d*), but little was added to the description.

The female measures 34–38 mm in length and 0.37–0.5 mm in thickness. According to Castellani and Willey "the head is slightly spatulate, with a sense-organ on each side near the front, the mouth is terminal, leading into a buccal capsule from which a short vestibule leads back to the œsophagus, the latter is 0.53 long or  $1/71$  of the total length." v Linstow states that the head is rounded, without teeth or papillae, and that the œsophagus is  $1/79$  of the total length.

The tail is attenuate and curved, and ends in a hemispherical knob. In front of this, according to v Linstow, there is a papilla on each side. Castellani and Willey state that the anus is shortly in front of the knob, v Linstow that an anus is absent. The vulva, according to the latter author, is situated at 0.44 mm from the anterior end. The eggs *in utero* are thin-shelled and measure  $0.018 \times 0.013$  mm, and the

worm is ovoviviparous. Castellani and Willey found microfilariae in the blood of the host. These were sheathed, and measured 0.14 mm in length, including the sheath, or 0.09 mm. without it. The tail of the microfilaria was blunt, but more attenuated than the head.

### 3 "*Filaria*" *haje* Wedl, 1862

*Hosts* —This species was recorded by Wedl from *Naja* [*Uræus*] *haje* in Egypt. His specimens were found on the outer surface of the lung, either free or coiled within flattened capsules of connective tissue. Baylis and Daubney (1922) doubtfully referred to the same species immature forms from the "intestine" of the cobra (*Naja tripudians*) and of the banded krait (*Bungarus fasciatus*) in India (probably in the Zoological Gardens, Calcutta).

Wedl's description is very brief, and is insufficient for the recognition of the species. The worms were 20–25 mm long and 1 mm thick. The cuticle is said to be thick and transversely ringed, the head without papillae, the mouth small and conical, the oesophagus and intestine wide, the former strongly muscular. The tail ends in a conical spike which, according to the figure, is curved dorsally. The specimens recorded by Baylis and Daubney were about 6–8 mm long, and lacked characters enabling them to be assigned to any well-established genus. The oesophagus had a relatively long posterior glandular portion.

### 4 '*Filaria*' sp

A single immature form, apparently different from "*F*" *haje*, was recorded by Baylis and Daubney (1922) from the "intestine" of a cobra (? *Naja tripudians*). It measured about 20 mm in length. The anterior end was broad and blunt, the posterior end more tapering, and the oesophagus was relatively shorter than in the specimens regarded as "*F.*" *haje*.

### 5 '*Filaria*' *emmæ* Stossich, 1897.

Synonym —"*Filaria* sp." Parona, 1889.

*Host* —*Oalotes emma*, Thagata, Mt Mulai-yit (Dawna Range), Tenasserim.

Of this form Parona had only female specimens, which are very summarily described\*. Their length is given as 140–190 mm. The body is more attenuated anteriorly than posteriorly. The mouth is unarmed, the oesophagus long and 0.023 [? 0.23] mm in diameter. The intestine is very narrow.

\* Stossich merely gave a name to the species, without having seen the specimens.

The tail is blunt and not mucronate The vulva is situated at 15 mm from the anterior end The "oviduct" [<sup>?</sup> vagina] is disposed in numerous loops

#### 6 "*Filaria*" *vivipara* v Linstow, 1904

*Host* —*Corvus splendens* (peritoneum), Colombo, Ceylon

Of this species the only description available is that given by v Linstow (1904), which is not sufficient to enable its position to be determined The type-specimens, which consisted of females only, are apparently not now available in the Colombo Museum

The female is 16–21 mm long and 0.32 mm thick Both ends of the body are rounded On each side of the head there is a small papilla The lateral fields occupy  $\frac{1}{8}$  of the circumference of the body The oesophagus measures  $\frac{1}{28}$ , the tail  $\frac{1}{85}$  of the total length The vulva is situated at 1.5–1.8 mm from the anterior end The eggs *in utero* measure  $0.039 \times 0.031$  mm The worm is viviparous The microfilariae have a rounded head and a pointed tail, and measure "0.043–0.364 mm" in length and  $5.2\mu$  in thickness "Presumably the embryos penetrate into the vascular system of the bird, where they live as blood-filariae"

#### 7 "*Filaria*" *plscicola* v Linstow, 1906

*Host* —A marine fish (<sup>?</sup> *Lethrinus* sp) ("from supra-orbital region"), Ceylon

Of this species, the type-specimen of which is apparently not available in the Colombo Museum, a very meagre description is given by v Linstow (1906, *d*) This reads as follows — "One incomplete female,  $225 \times 0.57$  [mm], the diameter at the head is 0.13 [mm], the head is rounded, destitute of lips, teeth, and papillae, the tail is lost from the specimen, genital orifice quite anterior, only 0.79 [mm] from cephalic extremity, eggs  $0.031 \times 0.023$  [mm], it is ovoviviparous, the embryos with acuminate tail measure  $0.53 \times 0.016$  [mm]"

### MICROFILARIÆ

The term *Microfilaria* Cobbold, 1880, is applied, as a collective and not as a generic name, to larval Filariidæ occurring in the blood-stream or in the tissues of vertebrates In addition to the microfilariae already referred to in connection with their respective adult forms, several, whose adult forms are unknown, have been described from Indian hosts In the following brief descriptions only the measurements and some of the more salient features are given For fuller details the original descriptions should be consulted Two of the

forms mentioned here (*Microfilaria malayi* and *M. actoni*) occur in man, one (*M. lewisii*) in the dog, one in the elephant, and the remainder in birds\*

1 *Microfilaria malayi* Brug, 1927 (Fig 28)

Synonym — *Filaria malayi* Brug, 1927.

Host — Man (in peripheral blood), recorded in Sumatra and other parts of the Malay Archipelago, and in China,

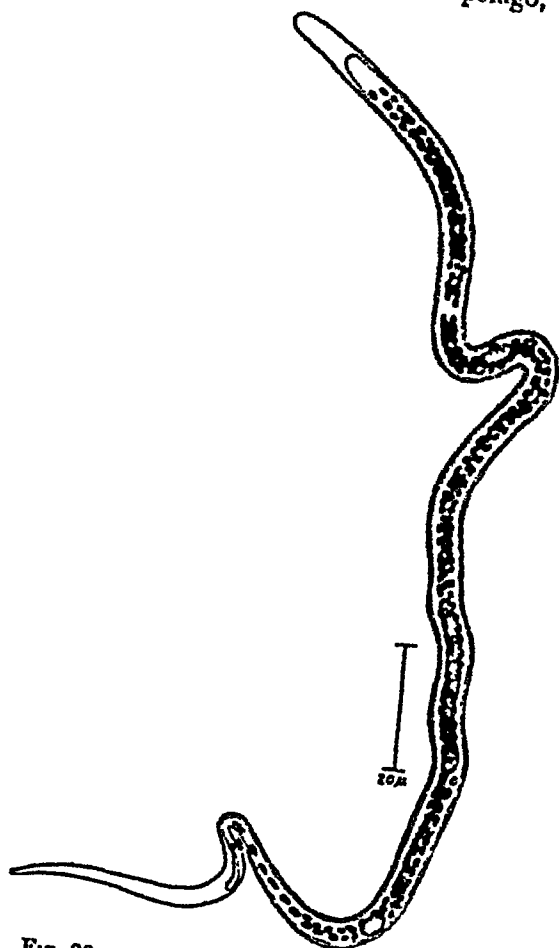


Fig 28 — *Microfilaria malayi*. (After Feng)

\* 27 species of " *Microfilarium* " have been described from birds in Portuguese India by I Frolano de Mello (1937, Rep 12th Internat Congress of Zoology (Lisbon, 1935), iii, pp 1533-1562), and to these another has been added by Frolano de Mello and L da Fonseca (1937 Proc Indian Acad Sci vi, 4, Sect B, pp 213-219)

Indo-China and Celebes. *Microfilaria* recorded by Korke (1929), in the district of Balasore on the coast of Orissa, and by Iyengar (1932), in the coastal regions of North Travancore, appear very probably to belong to this species, while Rao (1936) records *M. malayi* as the only human microfilaria occurring in the rural town of Patnagarh, Orissa

The dimensions of the larva, as is the case with other species, vary greatly according to the method of preservation employed. Its length, according to various authors (Faust (1929), Korke (1929); Brug ([? 1930]), Feng (1933)), is 0.152–0.298 mm, and its thickness 3.88–7 $\mu$ . The anterior end is bluntly rounded, and has a double stylet. The anal pore is visible as a clear space at about the posterior fifth of the body. The tail is thus relatively long. It is usually suddenly constricted to form a slender, sometimes thread-like, terminal portion which ends in a swelling containing a nucleus. This and another nucleus, usually situated just in front of the constriction, take nuclear stains more deeply than the rest of the nuclei of the body. A "sheath" is present, and this is much longer than the body.

This microfilaria displays a nocturnal periodicity in the peripheral blood. Its vectors are mosquitoes of the genera *Anopheles* and *Mansonioides*. Rao records *M. annuliferus* as the vector in Orissa.

### 2 *Microfilaria actoni* Rao, 1931.

*Host*.—Man (in peripheral blood); recorded in a convict in Comilla jail, East Bengal, who had come from Sandwip Island, at the mouth of the Brahmaputra River.

This microfilaria, according to Rao, bears some resemblance to that of *Dipetalonema persians* (which is not known to occur in India), but is much smaller. It measures 0.14–0.15 mm in length and 6 $\mu$  in maximum thickness, and is without a "sheath."

### 3 *Microfilaria lewisii* Korke, 1924.

*Host*.—Dog (in peripheral blood); Kasauli.

This larva, according to Korke (1924), measures 0.14–0.212 mm \* in length and 3.5–4 $\mu$  in thickness, and is without a "sheath." The anterior extremity is "more squarely cut than rounded, and sometimes adorned with a triangular stylet about 2 $\mu$  in height." The tail is said to taper to a fine point, but is figured as having a blunt tip.

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\* The maximum length given in the table of measurements, however, is 0.204 mm.

Korke considers that this microfilaria approaches most closely in length to those of *Dirofilaria immitis* and *Dipetalonema dracunculoides* (Cobbold). It is, however, more slender than either of these, and seems to the writer more comparable in size with the microfilaria of *Dipetalonema reconditum* (see p 7)

#### 4 *Microfilaria cephalocauda* Chandler, 1924.

*Host* —Racket-tailed drongo (*Dissemurus paradiseus*) (in blood), Zoological Gardens, Calcutta

This larva measures 0.18–0.205 mm in length and about  $48\mu$  in thickness. The body is of almost uniform thickness throughout, and both head and tail are bluntly rounded. A 'sheath' is present. This may be the microfilaria of *Chandlerella bosei* (see p 26) or of *Paraprocta brevicauda* (see p 49)

#### 5 *Microfilaria colubroides* Chandler, 1924

*Host* —Racket-tailed drongo (*Dissemurus paradiseus*) (in blood), Zoological Gardens, Calcutta

This larva measures 0.28–0.35 mm in length and about  $65\mu$  in thickness. The head is bluntly rounded, the tail slender and pointed. No 'sheath' was observed. This microfilaria may belong to *Chandlerella bosei* (see p 26) or to *Paraprocta brevicauda* (see p 49)

#### 6 *Microfilaria cissæ* Chandler, 1924.

*Host* —Hunting cissa (*Cissa chinensis*) (in blood), Zoological Gardens, Calcutta

This microfilaria measures 0.3–0.365 mm in length. Its 'sheath' is considerably longer. The thickness of the body is about  $7\mu$ . The head is bluntly rounded, the tail tapers almost to a point, but is truncate at the tip.

#### 7 *Microfilaria comma* Chandler, 1924

*Host* —Hunting cissa (*Cissa chinensis*) (in blood), Zoological Gardens, Calcutta

This larva has a length of 0.108–0.114 mm, and a maximum thickness of  $5.5\text{--}6\mu$ . The head is bluntly rounded and the tail pointed. The body begins to taper at about the middle of its length. There is a tight-fitting 'sheath,' 'obvious only at anterior end, where it exceeds the embryo by a few micra only'

8. *Microfilaria columbæ* Ray and Dasgupta, 1936

*Host* —“Pigeon” [*Columba livia*], Calcutta

Ray and Dasgupta (1936) record microfilarinæ, without “sheath,” from the blood of a pigeon. The parent worm was not found, but it is suggested by the authors that the larvæ may possibly have been those of *Eulimdana clara* (Wedl, 1856), a Filarid which occurs in pigeons. They varied in length between about 0.1 and 0.364 mm. The smallest forms showed little morphological differentiation, only the nerve-ring and anal pore being recognizable. The largest were considerably more advanced in development, but the authors considered that they belonged to the same species.

9 *Microfilaria* sp

Evans and Rennie (1910) record the finding of microfilarinæ in blood taken during the daytime from “quite a number” of elephants in Burma. The worms measured 0.18 mm in length and  $6\mu$  in thickness. Khalil (1922, b) suggests that they may have been the larvæ of one of the species of *Parabronema*, and that these may “void their embryos into the lymphatics or blood and not into the intestinal canal.”

## 2. Family PHILOMETRIDÆ Baylis and Daubney, 1926.

Synonym —Dracunculidæ Leiper, 1912

Medium-sized or large parasitic forms. Male, when known, much smaller than female. Body of female often much elongated. Anterior end rounded. Mouth simple, without lip-like structures, but surrounded by papillæ. Anus frequently non-functional or absent in the adult female. Two equal spicules and an accessory piece present in the male. Vulva very inconspicuous or absent, and vagina rudimentary or absent, in gravid females. Uterine branches directly opposed, forming a continuous tube. Ovaries relatively very short, situated at opposite ends of the body. Female viviparous. Adult worms parasitic in the body-cavity, serous membranes or connective tissue of vertebrates. The intermediate hosts, where known, are Crustacea.

*Key to Genera.*

- |  |                    |
|--|--------------------|
| Tail of female pointed and curled ventrally into a hook . . . . .        | DRACUNCULUS, p. 63 |
| Tail of female bluntly rounded . . . . .                                 | 1                  |
| 1. Male with a conically tapering tail . . . . .                         | MICROPLEURA, p. 59 |
| Posterior end of male truncate, with terminal cloacal aperture . . . . . | PHILOMETRA, p. 59  |

1 Genus **PHILOMETRA** Costa, 1846

Synonym —*Ichthyonema* Diesing, 1861

Body elongate, rounded at both extremities Lateral fields broad Mouth funnel-shaped Œsophagus relatively short, more or less swollen anteriorly and cylindrical posteriorly, and accompanied by a long dorsal unicellular gland which opens into it by a narrow duct near the mouth A pair of smaller subventral glands also present Anus non-functional in the adult female, the posterior end of the intestine being connected with the body-wall by a solid column of cells Tail of male truncate, with a pair of large lateral processes posteriorly Cloacal aperture terminal Spicules sharply pointed Accessory piece large and well developed Testis single Tail of female short and bluntly rounded Vulva at about the posterior third of the body Vagina apparently functional only in very young females, and subsequently losing its connection with the uterus Ovaries usually reflexed. Adult worms in the body-cavity, genital glands or connective tissue of fishes Larvæ, at least in some cases, in the body-cavity of Copepods

Genotype.—*Philometra globiceps* (Rudolphi, 1819).

1 *Philometra* sp Thwaite, 1927.

Host —*Balistes* sp (eye), Pearl Banks, Ceylon

Thwaite (1927) records two incomplete female specimens The longest fragment was about 150 mm long "Four large equidistant papillæ surrounded the head"

2 Genus **MICROPLEURA** v. Linstow, 1906

Cuticle without striations, but (at least in the female) with irregularly-distributed series of minute tubercles Œsophagus with a short anterior portion and a long and wider posterior portion Caudal end of male with a single, somewhat interrupted ala on the right side in the preanal region Tail conically tapering Several pairs of small, sessile caudal papillæ present Spicules short, very slender and tapering to fine points Accessory piece well developed Tail of female bluntly rounded, with a pair of large, prominent, subventral papillæ Vulva slightly in front of the middle of the body, very inconspicuous Vagina non-muscular near the vulva Ovaries usually reflexed Adult worms in the body-cavity and serous membranes of reptiles

Genotype.—*Micropleura vivipara* v Linstow, 1906.

1. *Micropleura vivipara* v. Linstow, 1906. (Figs. 29-31)

*Host*:—Gharial (*Gavialis gangeticus*) (body-cavity and serous membranes); Zoological Gardens, Calcutta (v. Linstow; Maplestone)

As has been pointed out by the writer (1924), the male form described under this name by v. Linstow probably belonged to a species quite different from the female. In the following description the characters of the male are taken from the writer's description, while those of the female are taken from the descriptions given by v. Linstow (1906, c), Baylis and Daubney (1922) and Maplestone (1930, b). The description by Baylis and Daubney was based in part on females from the type series in the Indian Museum.

The male measures 9.9–10.6 mm in length and 0.36–0.4 mm in maximum thickness, the female 37–43 mm. and 0.79–1 mm

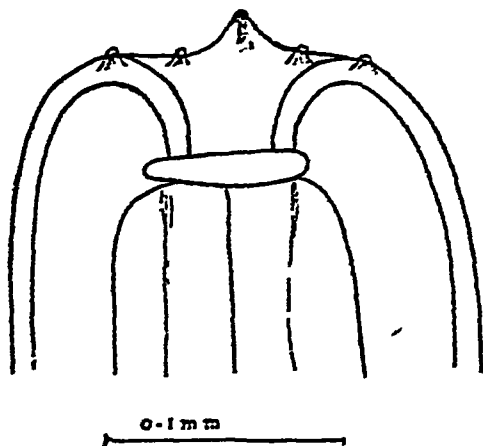


Fig. 29 — *Micropleura vivipara* Anterior extremity of female; lateral view. (After Maplestone)

respectively. The cuticle of the female bears little longitudinal series of from two to seven minute papilla-like structures, scattered rather irregularly over its surface, especially on the hinder portion of the body. The mouth is surrounded, according to Maplestone, by ten papillæ. Two of these are lateral and may form somewhat prominent conical structures. There are two subdorsal and two subventral papillæ, and on each side two sublateral papillæ near the base of the lateral papilla. The diameter of the head, at the level of the papillæ, is about 0.07 mm in the male and 0.15 mm in the female. The œsophagus is distinctly divided into a narrower, anterior, muscular portion (which is somewhat granular for nearly the posterior half of its length) and a wider, glandular, posterior portion. The entire œsophagus measures 1.8–2 mm in length

in the male and 3.25-3.5 mm. in the female, its anterior portion 0.44-0.5 mm. and 0.75-0.9 mm. respectively. The nerve-ring is situated near the hinder end of the anterior portion, at 0.38-0.4 mm. from the anterior end in the male and at 0.67-0.8 mm. in the female. The excretory pore is situated behind the junction of the two parts of the oesophagus, at 0.6 mm. from the anterior end in the male and at 1-1.1 mm. in the female.

The caudal end of the male is spirally coiled. The tail is

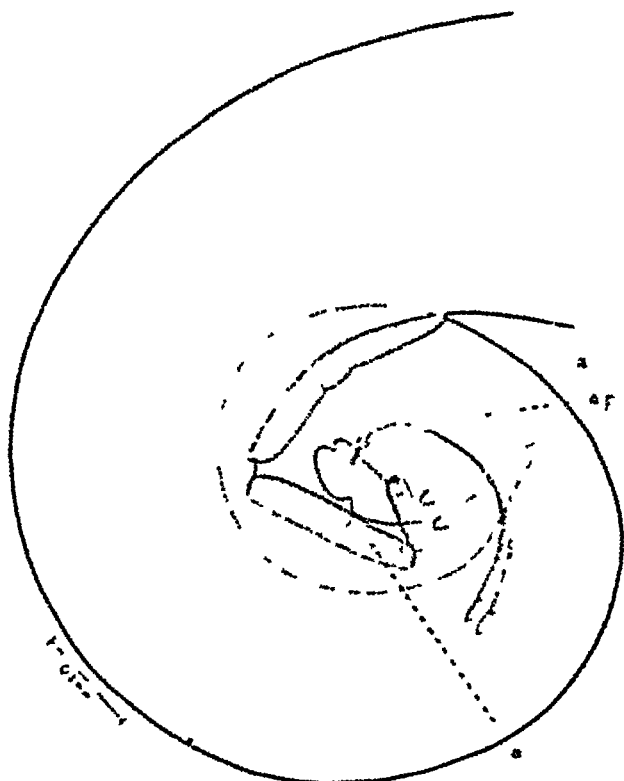


Fig. 30.—*Micropleura mupara*. Posterior end of male, lateral view. *a, a*, portions of the single ala of the right side, *a p*, accessory piece. The dotted portions of the tail are seen by transparency through the overlying coil of the body. (After Baylis.)

conically tapering and measures 0.5 mm. in length. There is a single caudal ala, which is situated on the right side, extends forward from a little in front of the cloacal aperture for some distance, and is somewhat interrupted. It shows well-marked transverse striations. There are seven pairs of

subventral caudal papillæ, of which four are postanal and three preanal. The two most anterior papillæ on each side are close together, those on the right side being situated dorsally to the ala. The next two pairs of papillæ are also close together, one just in front of the cloacal aperture and one just behind it. The remaining papillæ are very prominent and conical. There is no pair of "roundish elevations" at the base of the tail, as described and figured by v Linstow. The spicules are equal (0.3–0.33 mm) in length, very slender and tapering to fine points. There is a well-chitinized accessory piece, measuring 0.07 mm in length.

The tail of the female, in the material described by Baylis and Daubney, was 0.2–0.35 mm. long. Maplestone considers, however, that these were contracted specimens, and states that in his material the tail was much longer. The tip of

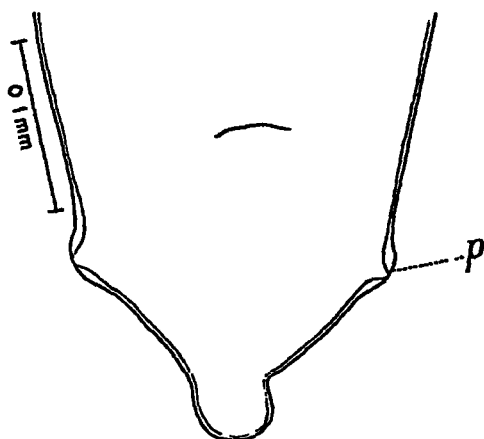


Fig. 31 — *Micropleura vivipara*. Posterior end of female, ventral view. *p*, papilla. (After Baylis and Daubney)

the tail is rounded and has a thickened cuticle. There is a pair of large, prominent, lateral or slightly subventral papillæ at a distance of 0.1–0.14 mm (or about 0.23 mm, according to Maplestone's figure) from the tip. The vulva is situated slightly in front of the middle of the body, but is very difficult to detect in mature females. The vagina consists of a very narrow, non-muscular duct running through the body-wall in a postero-dorsal direction from the opening, and a very short, somewhat muscular portion returning towards the head and connected with the uterus. The whole of the vagina is not more than 0.4 mm in length. The two branches of the uterus are directly opposed, forming a continuous, straight tube joining the ovaries, which are situated at opposite ends of the body-cavity. This tube fills the whole width of the body-cavity with the exception of the space occupied by the

very narrow intestine, which runs in close contact with the body-wall. The ovaries are very short and are usually reflexed, but occasionally continue in a straight line with the uterus, with the respective ends of which they are connected by narrow ducts. The development of the embryos appears to be very rapid, the uterus being entirely filled, from end to end, with young apparently fully formed and not enclosed in membranes. These embryos have a cuticle marked with conspicuous transverse striations, a blunt head and a long, tapering tail. They measure, according to v Linstow, 0.57 mm. in length and 0.017 mm. in thickness.

### 3 Genus **DRACUNCULUS** [pre-Linnean authors] Reichard, 1759

Synonyms — *Vena* [pre-Linnean authors] Gallandat, 1773, *Furia* Linnæus, 1758 (part); *Vermiculus* Dunghison, 1895, *Fuellebornius* Leipert, 1926.

Body greatly elongate, especially in the female. Head with a cuticular thickening or shield. Lateral fields broad. Oesophagus with a very short anterior portion and a long posterior portion. Into the former there open a large dorsal and two smaller subventral unicellular glands. Intestine rudimentary and anus non-functional in the adult female. Spicules of male filiform. Several pairs of sessile caudal papillæ present. Tail of female pointed and curled ventrally into a small hook. Vulva near the middle of the body, but very difficult to observe in mature specimens. Adult worms in the connective tissue of vertebrates. Larvæ, when known, in the body-cavity of Copepods.

Genotype — *Dracunculus medinensis* (Linnæus, 1758)

#### 1 *Dracunculus medinensis* (Linnæus, 1758) Gallandat, 1773 (Fig. 32)

Synonyms — [*Dracunculus persarum*, *Vena medina*, *Vena dracunculus*, pre-Linnean], *Gordius medinensis* Linnæus, 1758, *Vena medinensis* Gallandat, 1773, *Dracunculus græcorum* Gruner, 1777, *Filaria medinensis* Gmelin, 1790, *Furia vena medinensis* Modeer, 1795, *Filaria tropica* Rudolphi, 1809; *Vermis medinensis* Diesing, 1851, *Filaria æthiopica* Valenciennes, 1856, *Dracunculus æthiopicus* Diesing, 1861, *Filaria guineensis* Dunghison, 1893, *Vermiculus capillaris* Dunghison, 1895, *Microfilaria medinensis* Neumann and Mayer, 1914, *Fuellebornius medinensis* Faust, 1929.

*Hosts* — This species (the "Guinea-worm") is a common parasite of man in many of the warmer portions of the world. It occurs in almost all parts of India, and in Assam, Burma and the Andaman Islands. The most heavily infested areas, according to Turkhud (1919), are in the south of India (the

western portion of the Madras Presidency and Mysore, and the Deccan) Besides man, various domestic and wild mammals have been recorded as hosts for *Dracunculus*. These include the dog, horse, ox, sheep, goat, jackal, wolf, fox, cheetah and leopard. Turkhud (1920) mentions Indian records from the dog and horse, from the Indian gazelle (*Gazella bennetti*) in the wild state, and from the leopard and Arabian baboon in captivity. The specific determination of the parasite cannot, however, be regarded as definitely established in all these cases. Turkhud has recorded the occurrence of a specimen among the dorsal muscles of the neck of a cobra (*Naja tripudians*) at Bombay, but this, as Hsü

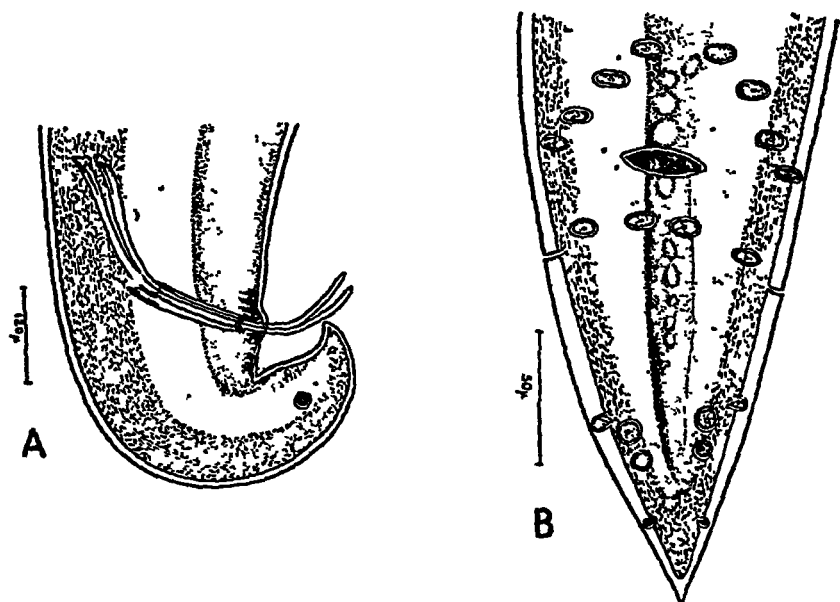


Fig 32 —*Dracunculus medinensis* Posterior end of male  
A, lateral view, B, ventral view (After Moorthy)

(1933) suggests, is more probably referable to *D. houdemeri* Hsu, 1933, a species recorded from *Natrix piscator* in French Indo-China, than to *D. medinensis*\*

The male worm is very rarely found. The female occurs in the subcutaneous connective tissue, most commonly of the lower limbs, and when gravid comes to the surface, the site of its anterior end being marked by a blister of the skin which breaks down to form an ulcer.

The male had never been adequately described until recently, when Moorthy (1937, a) gave an account of specimens

\* Mirza and Basir (1937) record what they believe to be *D. medinensis* from *Varanus* sp. at Allahabad.

obtained experimentally in dogs. These measured 12-20 mm. in length and 0.4 mm in thickness, but according to other authors the male may measure up to 10 mm in length. The adult female varies in length from about 320 to 1200 mm., and measures 0.5-1.7 mm in maximum thickness. The mouth is small, and is situated on an oval or quadrangular elevation in the centre of a cuticular thickening or shield. According to Moorthy's description it is surrounded by an inner circle of six papillæ, two of which are lateral, two subdorsal and two subventral. The subdorsal and subventral papillæ may, however, be partially fused so as to form double papillæ. There is also an outer circle of four double papillæ, and a pair of lateral organs ("amphids"), situated behind the lateral papillæ of the inner circle. Hsu's (1933) interpretation of the papillæ agrees essentially with Moorthy's. He finds one pair of single lateral papillæ, two pairs of submedian papillæ with double terminations, and also a dorsal and a ventral median papilla, likewise with double nerve-endings, situated more anteriorly, close to the mouth\*. The oesophagus consists of a short and narrow anterior muscular portion and a wider posterior glandular portion. In the male it is 9.6 mm long. In adult females from North American animals, according to Chitwood (in Moorthy), it may be as much as 40-60 mm long. The nerve-ring surrounds the posterior portion, which is constricted at this point, at a distance of about 0.6 mm in the male, or 1 mm in the female, from the anterior extremity. There is a pair of cervical papillæ just behind the nerve-ring.

The tail of the male is 0.25 mm long, and is conically pointed. There are ten pairs of caudal papillæ, four preanal and six postanal, arranged as shown in fig 32. There is also a pair of lateral "caudal pores," or "phasmids," behind the second pair of postanal papillæ. The spicules are subequal and measure 0.49-0.73 mm in length. There is an accessory piece, 0.2 mm long.

In young females, 24 mm in length, the tail is 0.25 mm long and ends in four spine-like processes. In the adult female it is 0.9 mm long and has a simple, ventrally-curved, spine-like termination. The anus is apparently non-functional in the adult. The vulva is situated at 10.3 mm from the anterior end in a young specimen 24 mm long. In such specimens the vagina, according to Moorthy, is closed by a mucoid plug, copulation having apparently already taken place. From his figure it appears to be about 0.25 mm long.

\* Boulenger (1928) also observed these dorsal and ventral papillæ, but considered them not homologous with the other papillæ, but rather cuticular thickenings more comparable with the "teeth" or "lips" often present in *Filarids*.

In gravid females the vulva is either completely obliterated or extremely difficult to detect. The body-cavity is almost completely filled by the uterus, which forms a continuous tube, ending in a short ovary at each end of the body. The vulva probably never functions as a birth-pore. If the affected part of the host comes in contact with water, the anterior end of the worm is protruded, and a rupture of the uterus and body-wall occurs, allowing the embryos to escape.

The embryos measure 0.5–0.75 mm in length and 0.015–0.03 mm in thickness, and have blunt heads and long, slender tails\*. The oesophagus is about 0.136 mm long.

The development of the embryos, after being discharged into water, depends upon the presence of certain "water-fleas" (various species of *Cyclops*, including *C. coronatus*, *C. bicuspidatus* and *C. quadricornis*). According to Lindberg (1935) the principal vectors in the Deccan are *Cyclops leuckarti* and a species which he has designated *C. vermifer*. Moorthy and Sweet (1936, b) found *C. leuckarti* and *C. hyalinus* naturally infected in Mysore, and obtained development of the embryos in three other species experimentally. The embryos are swallowed by the *Cyclops*, and migrate through the wall of the gut into the body-cavity, where they undergo two moults, but do not grow. Infection of the final host takes place through drinking water containing infested *Cyclops*, and the worm is believed to take about a year to reach maturity. In India the principal sources of infection appear to be the wells and tanks from which drinking-water is obtained, and the spread of infection might be limited by preventing the contact of the legs and feet of the water-carriers with the water. There is some seasonal variation in the incidence of infection, doubtless depending on the habits of *Cyclops*. In the Deccan, according to Lindberg, the maximal incidence in human beings occurs from March to May (just before the onset of the monsoon), and cases disappear during the latter half of the year.

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\* Moorthy and Sweet (1936, a) have described an abnormal type of embryo met with in human infections in the Chitaldrug district of Mysore. This was obtained from the same parent worm as the normal type, but in small numbers, and was characterized by the possession of a short tail having a knob-like projection at its base, and posteriorly to this knob, on the same side of the tail, a tapering and pointed tail-like projection almost at right angles to the body. The average length of these embryos was only 0.434 mm, and the oesophagus was shorter than in normal embryos (0.112 mm).

### 3. Family SPIRURIDÆ Orley, 1885.

Mouth typically with two more or less well-developed lateral lips, which may be simple or trilobed. Where the lips are well developed, they carry at least the lateral cephalic papillæ, and frequently also the submedian papillæ. A pharynx or buccal capsule is usually present. The position of the vulva is variable, but it is never very close to the anterior end. Females usually oviparous, exceptionally ovoviviparous or viviparous. Adult worms in the alimentary canal, urinating a tendency to burrow in the walls of the organs inhabited. First- and second-stage larvæ probably always parasitic in Arthropods. Third-stage larvæ parasitic in these or in vertebrates, and transmitted to the final host by ingestion.

#### Subfamily SPIRURINÆ Raillet, 1915

Lips usually followed by a cuticular collar which is prominent dorsally and ventrally, and may form dorsal and ventral shields overlapping the lips. A pharynx or buccal capsule present, without spiral or annular thickenings. Prenal papillæ of male usually four pairs. An accessory piece usually present.

#### Key to Genera

- |   |    |                    |
|---|----|--------------------|
| Dorsal and ventral cephalic shields absent.                     | 1  | PROTOSPIRURA, p 68 |
| Dorsal and ventral cephalic shields present                     |    |                    |
| 1 Six auricular appendages present near the anterior end        | 1  |                    |
| 2 Auricular cephalic appendages absent                          | 2  | PARABRONEMA, p 92  |
| Pharynx funnel-shaped and formed of separate lateral halves     |    |                    |
| Pharynx cylindrical or laterally compressed                     | 3  | DRASCHIA, p 89     |
| 3 A hump or holdfast present on the ventral surface of the body |    |                    |
| Body without ventral hump                                       | .. | SPIRURA, p 67      |
|   |    | HABRONEMA, p 71    |

#### 1 Genus SPIRURA Blanchard, 1849, *nec* Diesing, 1861

Lips small, trilobed, surrounded at their bases by a projecting cuticular collar which is specially prominent dorsally and ventrally. Buccal capsule laterally compressed. Body thickened posteriorly and somewhat spirally coiled. Body-wall raised into a ventral hump, serving as a holdfast, at some

distance from the anterior end Cervical alæ absent Caudal end of male with well-developed alæ Four pairs of pedunculate preanal papillæ and a single median precloacal papilla present Postanal papillæ about five pairs Spicules unequal, the shorter alate An accessory piece present Tail of female bluntly conical and curved ventrally Vulva in the middle region of the body. Uterine branches opposed Adult worms in the alimentary canal (usually the stomach) of insectivores, carnivores and rodents

Genotype.—*Spirura talpæ* (Gmelin, 1790)

### 1 *Spirura narayani* Mirza and Basir, 1938

*Host*—Mongoose (*Herpestes mungo*) (stomach), Hyderabad

This species is very briefly described The male measures 25 mm in length and 0.5 mm in thickness, the female 25–40 mm and 0.4–0.57 mm respectively. The ventral hump is situated at a distance of 1.8 mm from the anterior end in a female 25 mm long

The male has three (or occasionally only two) pairs of pedunculate postanal papillæ Two pairs of small papillæ are also figured near the tip of the tail A median precloacal papilla was not seen The right spicule is the longer, measuring 0.68 mm, and is broad and alate The left spicule is 0.16 mm. long

The vulva is situated at 8 mm from the posterior end. The eggs measure  $0.037 \times 0.024$  mm

It seems possible that this species may be identical with *S. gastrophila* (Muller, 1894) Seurat, 1913 [ $?=S. rhytipleurites$  (Deslongchamps, 1824)], which has also been recorded from *Herpestes* There appears, however, to be considerable doubt as to the status of the forms attributed by different authors to *S. gastrophila* and *S. rhytipleurites*

### 2 Genus PROTOSPIRURA Seurat, 1914

Synonyms.—*Cephalacanthus* Diesing, 1853 (part); *Mastophorus* Diesing, 1853 (part)

Lips trilobed, each lobe bearing a series of forwardly-projecting teeth on its inner surface Dorsal and ventral cephalic shields absent Lateral alæ absent Pharynx cylindrical or somewhat laterally compressed Caudal end of male spirally coiled and provided with well-developed alæ, four or five pairs of preanal and two or three pairs of postanal papillæ with short peduncles, and a group of small, sessile papillæ near the tip of the tail An unpaired precloacal papilla typically present. Right spicule longer and stouter than the

left, which is alate distally. An accessory piece present. Tail of female short. Vulva in the middle region of the body. Adult worms in the stomach of mammals.

Genotype.—*Protospirura numidica* Seurat, 1914.

1 *Protospirura muris* (Gmelin, 1790) Seurat, 1915 (Fig 33)

Synonyms.—*Lumbricus muris domesticus rimator* Werner, 1782; *Ascaris muris* Gmelin, 1790, *Ascaris obtusa* Fröhlich, 1791; *Fascaria muris* Zeder, 1803; *Lumbricus muris* Rudolphi, 1809; *Spiroptera obtusa* Rudolphi, 1819; *Filaria obtusa* Schneider, 1856; *Filaria muris* Stossch, 1897, *Spiroptera brauni* v. Linstow, 1897.

Hosts:—This is a common parasite of the stomach of rats and mice, and has been recorded from almost all parts of the

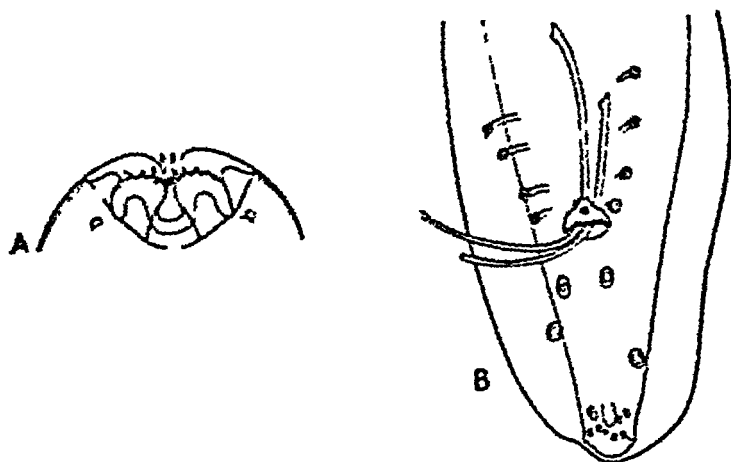


Fig 33—*Protospirura muris*. A, anterior extremity, ventral view; B, posterior end of male, ventral view (After Seurat.)

world v. Linstow (1904) has recorded it from the brown rat (*Rattus norvegicus* [= *Mus decumanus*]) at Colombo, Ceylon, and there are specimens in the British Museum (Natural History) from the black rat (*Rattus rattus*) at Lyallpur, Punjab.

The male measures about 13–35 mm in length and 0.5–1.25 mm in maximum thickness, the female about 15–40 mm. and 1.1–1.75 mm respectively. The body is relatively stout, but tapers considerably in the anterior half. The cuticular striations are at intervals of about  $4.6\mu$ . The diameter of the head is 0.18–0.24 mm in the male and 0.26–0.28 mm in the female. Each lip consists of three distinct lobes, the median lateral lobes being larger than the subdorsal and subventral. Each lobe bears on its inner surface at the apex a number

(usually from four to seven) of denticles, one of which usually occupies a central position and is larger than the others. The submedian papillæ are at the bases of the subdorsal and subventral lobes. The pharynx measures (in the male) from 0.14 mm. to nearly 0.3 mm. in length, and about half as much in internal diameter. It is connected by numerous parenchymatous strands with the body-wall. The œsophagus is about 3.3–3.6 mm. long and 0.2 mm. in maximum thickness in the male, and 4.3–4.8 mm. long and 0.45 mm. thick in the female. The nerve-ring is situated at about 0.4–0.65 mm. from the anterior end in the male, the cervical papillæ at 0.57–0.6 mm., and the excretory pore at 0.56–0.73 mm.

The caudal end of the male is coiled in two or three turns of a spiral. The tail is about 0.65–0.69 mm. long, and has a blunt tip. The caudal alæ are well developed and broad, and measure about 8.7 mm. in length. The ventral surface of the caudal region and alæ is covered with quadrangular cuticular elevations arranged in longitudinal rows. There are four pairs of large, pedunculate preanal papillæ and two pairs of similar postanal papillæ, the posterior of these being situated at about the middle of the tail. Subventrally, near the tip of the tail, there are four or five pairs of very minute sessile papillæ. There is also a median papilla on the anterior lip of the cloacal aperture. The right spicule is longer and stouter than the left. It measures about 1–1.2 mm. in length, while the left spicule measures about 0.84–1 mm. Both spicules have a funnel-shaped expansion at the root and a rather blunt tip, that of the right spicule bearing a number of minute spiny processes. The accessory piece is 0.155 mm. long, and is described as ploughshare-shaped by Seurat (1916).

The tail of the female is curved towards the dorsal side and has a bluntly-rounded tip. It measures about 0.5–0.52 mm. in length. The vulva is situated somewhat in front of the middle of the body (at about 12–16 mm. from the anterior end), and is not prominent. The vagina runs posteriorly from it, with a somewhat convoluted course. The combined length of the vagina and the common trunk of the uterus is about 1 mm. The uterine branches are at first parallel, but one of them turns forward and extends to about the level of the posterior end of the œsophagus. The eggs are elliptical and measure about  $0.046\text{--}0.056 \times 0.03\text{--}0.032$  mm.

The life-history of this species involves mealworms (the larvæ of beetles of the genus *Tenebrio*) as intermediate hosts. If the eggs passed in the feces of rats and mice are swallowed by a mealworm, the larvæ hatch and penetrate into the body-cavity, where they become encapsuled and develop to the third stage. If the mealworm is then eaten by a suitable host, the larvæ complete their development in the latter.

3 Genus **HABRONEMA** Diesing, 1861

Synonyms — *Dermofilaria* Rivolta, 1884 (part); *Cyrnea* Sourat, 1914, nec Deshayes, 1858, *Neurocyrnea* Strand, 1929

Lips entire or trilobed, overlapped by dorsal and ventral cuticular shields. Teeth sometimes present on the inner surfaces of the lips. A single lateral ala, or a pair of alae, usually present in the cervical region. Pharynx cylindrical or laterally compressed. Caudal end of male with broad alae. Several (most commonly four) pairs of pedunculate preanal papillae present, and two or more pairs of similar postanal papillae. Spicules very unequal (the left usually the longer) and dissimilar. Accessory piece usually well developed. Vulva variable in position. Female oviparous. Adult worms in the stomach of mammals, or in the proventriculus and gizzard of birds.

Genotype — *Habronema muscae* (Carter, 1861)

## Key to Species

Parasites of mammals	..	1
Parasites of birds	...	3
1 Parasite of pangolin	..	<i>schollei</i> , p 76
Parasites of Equidae	..	2
2 Longer spicule of male more than 2 mm long; vulva displaced from ventral surface; vagina at first a narrow subcuticular tube		<i>muscae</i> , p 71.
Longer spicule of male less than 1 mm long; vulva ventral; vagina with large globular ojector		<i>microstoma</i> , p 75.
3 Longer spicule of male less than 2 mm. long		4
Longer spicule of male more than 2 mm long		9
4 Longer spicule 1 mm or more in length		5
Longer spicule less than 1 mm long		8
5 Shorter spicule 0.4 mm or more in length		6
Shorter spicule less than 0.4 mm long		7
6 Vulva in front of middle of body		<i>magnilabiatum</i> , p 85.
Vulva near posterior end of body		<i>euplocan.</i> , p 82
7 Vulva slightly behind middle of body		<i>imbricatum</i> , p 83
Vulva near posterior end of body		<i>diesingi</i> , p 84
8 Vulva in front of middle of body		<i>asymmetricum</i> , p 86
Vulva near posterior end of body		<i>indicum</i> , p 80
9 Parasite of peafowl		<i>bulbosum</i> , p 78
Parasite of cassowary		<i>casuari</i> , p 88

1 *Habronema muscae* (Carter, 1861) Diesing, 1861 (Figs 34, 36)

Synonyms — *Filaria muscae* Carter, 1861, *Spirura muscae* Marotol, 1913, ? *Dermofilaria irritans* Rivolta, 1884, ? *Filaria irritans* Railliet, 1885

Hosts — Horse, donkey, mule and zebra; usually in the mucosa of the cardiac portion of the stomach, either free

or with the anterior end buried in the gastric glands. Some ulceration of the gastric lining may be produced. The worm also sometimes occurs in the intestine (cæcum and colon). The distribution of this species is world-wide. It has been recorded in India from Madras, Bombay, Hyderabad, the United Provinces, the Punjab and the North-west Frontier Province. There are specimens in the British Museum (Natural History) from Ceylon.

The male measures 8–14 mm in length and 0.25–0.3 mm. in maximum thickness, the female 13–22 mm and 0.25–0.4 mm. respectively. The cuticle has well-marked transverse

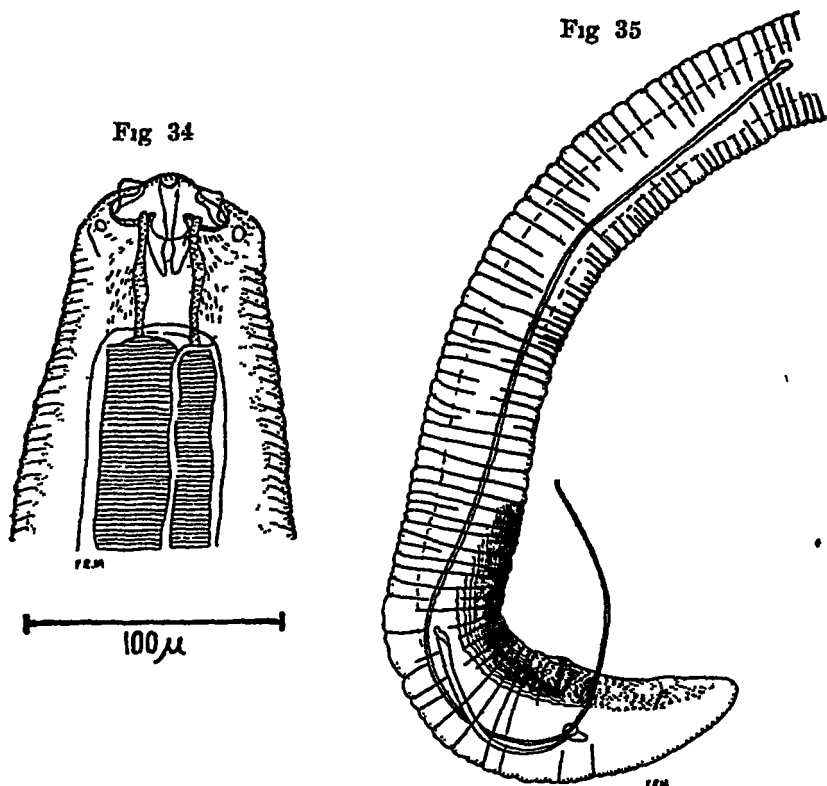


Fig 34 —*Habronema muscæ* Anterior end, lateral view.  
(From Baylis, after Ransom)

Fig 35 —*Habronema muscæ* Posterior end of male, lateral view  
(From Baylis, after Ransom)

striations. There is a lateral ala on the left side only, beginning behind the cervical papilla of that side and extending in the male to about the middle of the body, and in the female to the neighbourhood of the vulva. The head is somewhat rounded in outline. The lips are trilobed. The median lobe of each lip is nearly quadrangular, and bears the lateral papilla near its anterior border. The pharynx is cylindrical

and measures about 0.048 mm in length in the male and 0.052–0.059 mm in the female. Its maximum diameter is about 0.016–0.022 mm. The oesophagus measures (in the female) 2.3–3.5 mm in length. The cervical papillæ are bristle-like and are situated at about the level of the nerve-ring, which is about 0.23 mm from the anterior end in the male, and 0.3 mm in the female.

The caudal end of the male is curled ventrally and usually forms a single turn of a spiral. The caudal alæ are narrow and almost symmetrical, and extend to the tip of the tail. The ventral surface of the alar region bears longitudinal ridges.

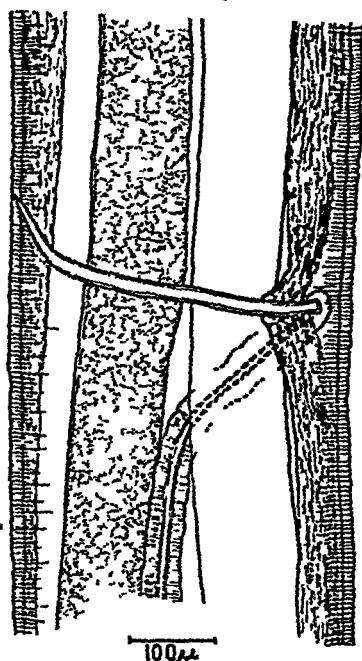


Fig. 36—*Habronema muscæ*. Vulvar region of female (After Ransom.)

or rows of cuticular vesicles. There are four pairs of pedunculate preanal papillæ (two of which are more or less adanal), and one pair of similar papillæ at about the middle of the tail. A little in front of this, on the left side only and nearer to the middle line, there is a single papilla. Near the tip of the tail there is a group of 10–12 minute sessile papillæ. The left spicule measures about 2.5 mm in length and has a thickness, at its middle, of about  $5\mu$ . Its tip is sharply pointed. The right spicule is also pointed, but is stouter, measuring about 0.5 mm in length and  $10\mu$  in thickness in the middle. There is a small, irregularly-shaped accessory piece.

The tail of the female is rather stout, bluntly rounded at the tip and curved dorsally. It is 0.3–0.35 mm long. The vulva is situated at about the anterior third of the body. It is very small, and is not ventrally situated but displaced towards the dorsal side, or even beyond this to the left side. From it the vagina passes round the body to the right side as a narrow tube in the thickness of the body-wall, being at first less than  $15\ \mu$  in diameter and without a muscular coat. It then enters the body-cavity and is provided with a coat of muscles. Passing posteriorly, it gives off the uterine branches at a distance of about 1.5 mm behind the vulva. The eggs are elongated, and their shells are very thin membranes, measuring at first  $0.04\text{--}0.05 \times 0.01\text{--}0.012$  mm, but later becoming further elongated with the development of the embryos.

This species was first recorded by Carter (1861) in the larval stage in house-flies in Bombay. Ransom (1911, a; 1913) showed that the forms described by Carter were the larvæ of a parasite of horses, and described the life-history and morphology of the worm. Ransom's account of the life-history was confirmed and amplified by Hill (1918), by Johnston and Bancroft (1920) and by Roubaud and Descazeaux (1922, a & b). The larvæ hatch in the intestine of the equine host and are passed out with the fæces. If ingested by the larvæ of flies—various Muscidæ, including the house-fly (*Musca domestica*) and several other species of *Musca*, *Sarcophaga* and *Pseudopyrellia*—they penetrate the wall of the gut and enter the body-cavity. Here they enter cells of the fat-body and undergo two moults. The walls of the cell in which the larva lies are gradually distended and thickened, forming an envelope round it. The larvæ pass through the metamorphosis of the fly, and reach the third or infective stage at about the time of its emergence from the puparium. They then migrate to the head of the fly, and when the latter feeds on the moist surface of the lips or nostrils of equine animals, or on open sores, they escape through the interlabellar membrane of the proboscis. Ransom and Hill believed that horses became infected by swallowing flies, alive or dead, with their food, and this may sometimes be the case. The larvæ may, however, also enter the mouth or nostrils actively. If they enter the mouth they reach the stomach, where they grow to maturity. If deposited on cutaneous sores, they may set up the persistent, itching, granular ulcers\* variously known as "summer sores," granular dermatitis or, in India, "bursattee" (bursati), but do not become adult worms.

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\* See also *Habronema microstoma* (p. 75) and *Draschia megastoma* (p. 89).

## 2 *Habronema microstoma* (Schneider, 1866) Ransom, 1911 (Fig 37.)

Synonyms — *Spiroptera megastoma major* [Gurll, 1831] Diesing, 1851; *Filaria microstoma* Schneider, 1866; *Spiroptera microstoma* Zürn, 1872; ? *Filaria stomoxeos* v. Linstow, 1875; ? *Dermofilaria irritans* Rivolta, 1884, ? *Filaria irritans* Railliet, 1885, ? *Spiroptera stomoxeos* Seurat, 1916

*Hosts*.—Like *H. muscæ*, this is a common and widely-distributed parasite of the horse tribe (horse, donkey, mule and zebra), and occurs free in the stomach or partly embedded in the mucosa of its wall. In India it has been recorded from Madras, Hyderabad, the United Provinces, the Punjab and the North-west Frontier Province

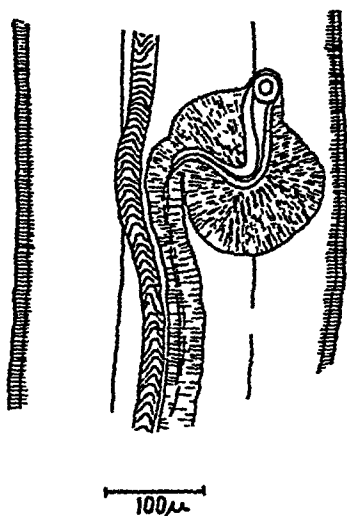


Fig 37 — *Habronema microstoma* Vulvar region of female (After Ransom)

The male measures 9–22 mm in length and 0.25–0.4 mm. in maximum thickness, the female 15–35 mm and 0.33–0.56 mm respectively. The cuticle has well-marked transverse striations. There is a lateral ala on the left side only, of similar extent to that of *H. muscæ*. The head is more square and truncate in appearance than in that species. The lips are trilobed. From the dorsal and ventral cephalic shields tridentate processes project between the lips into the buccal cavity. The pharynx has an average length of about 0.075 mm, and is somewhat wider than in *H. muscæ*. The oesophagus (in the female) is 3–3.8 mm long. The nerving and cervical papillæ are situated at 0.28–0.36 mm from the anterior end.

The caudal end of the male is similar to that of *H. muscæ*. The four pedunculate preanal papillæ of the left side are placed a little further forward than those of the right. There are two pedunculate postanal papillæ on each side, but those of the left side are close to the cloacal aperture, while those of the right are much more posterior, near the tip of the tail. As in *H. muscæ*, there is a group of 10-12 minute sessile papillæ at the tip of the tail. The left spicule is about 0.76-0.8 mm long, and has a thickness, at its middle, of about  $15\mu$ . The right spicule measures about 0.35-0.38 mm in length and about  $20\mu$  in thickness in the middle, and ends in a point, with a small barb at about  $6\mu$  from the tip. The accessory piece is small and irregularly shaped.

The tail of the female is 0.44-0.52 mm long, and is shaped as in *H. muscæ*. There may be some small cuticular tubercles at its tip. The vulva is rather large, and is ventrally situated, slightly behind the anterior third of the body. Immediately behind it there is a large, globular, muscular ovejector, measuring 0.15-0.2 mm in diameter, the narrow lumen of which describes an S-shaped curve. From the ovejector the muscular vagina, which is 0.04-0.05 mm in diameter, runs back to a point about 1-1.4 mm from the vulva, where it gives off the uterine branches. The eggs measure  $0.045-0.049 \times 0.016$  mm.

The life-history of this species, according to the observations of Hill (1918) and of Roubaud and Descazeaux (1922, *a* & *b*), is similar to that of *H. muscæ*, the intermediate hosts being Muscid flies and including the house-fly (*Musca domestica*). The principal vector, however, appears to be the stable-fly (*Stomoxys calcitrans*), which has blood-sucking habits. The larvæ escape through the articular membrane of the labella of this insect when it bites.

### 3 *Habronema zschokkei* (Meyer, 1896) (Fig. 38)

Synonyms — *Filaria zschokkei* Meyer, 1896, *Spiroptera orca* v. Linstow, 1906, ? *Ascaris manidis* Diesing, 1851.

*Host* — Indian pangolin (*Manis pentadactyla*), Ceylon.

Meyer (1896) gives a fairly full description of *Filaria zschokkei*, from the intestine of this animal in Ceylon. v. Linstow (1906, *d*) briefly describes *Spiroptera orca* from the stomach of the same host at Horana, Ceylon. Diesing's species *Ascaris manidis* is based on records by Gouye (1703) and Whitefield (1830). Gouye records in the upper part of the stomach of a "lizard," called by the natives "phatagen" and by Aldrovandus *Lacerta Indica squamosa*, a "bourse pleine de Vers vivans, gros et longs comme des épingles." Whitefield mentions the occurrence of "a vast number of worms of the

*Ascaris* genus" (not further named or described) in a saccular structure (apparently normal to the animal) of the stomach-wall. Diesing gives the length of this worm as up to an inch, and its thickness as  $\frac{1}{4}$  line, but there is no further description. It is doubtful whether Diesing's species is the same as that of the later authors, but, in spite of some discrepancies between Meyer's and v Linstow's descriptions, it seems almost certain that *Spiropteraorca* is synonymous with *Filaria zschokkei*. In the same paper in which he describes *S. orca*, v Linstow records immature specimens from the peritoneum of *Manis pentadactyla*, which he refers to "*Filaria zschokkei*," but does not describe. Although v Linstow's type-specimens of *S. orca* do not appear to be available in the Colombo Museum, the writer has had the opportunity of examining these im-

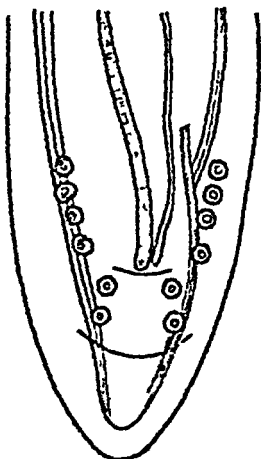


Fig 38.—*Habronema zschokkei*. Posterior end of male, ventral view (After v. Linstow)

mature specimens, which proved to have nothing to do with *F. zschokkei*, but to be immature *Ascarids*.

The male, according to Meyer, measures 19–24 mm in length and 1.1 mm in thickness, the female 25–35 mm and 1.3 mm respectively. According to v Linstow, the male measures up to 25 mm in length and 0.71 mm in thickness, the female 32 mm and 0.95 mm. v Linstow states that the cuticle has coarse rings  $53\mu$  apart, and finer rings  $5.4\mu$  apart. The head, according to Meyer, has four lips, of which the lateral are the largest. The anterior edges of the lips are sharp and curved inwards, and each lip has two papillæ at its base. According to v Linstow, there are large dorsal and ventral lips, expanded in front, and "behind these in the submedian lines 4 finger-shaped procumbent processes"

Both authors mention a "vestibule" [pharynx], v. Linstow giving its length as 0.2 mm. and Meyer as 0.114 mm. The latter author states that it has a coat of circular fibres. Meyer describes a dorsal and a ventral blunt-tipped conical tooth at its entrance. The œsophagus according to Meyer, is one-fifth of the total length, and widens rather suddenly a little behind the excretory pore. It apparently shows the usual division into two portions. According to v. Linstow, the œsophagus is  $\frac{1}{3}$  to  $\frac{1}{3}$  of the total length. The nerve-ring, according to Meyer, is a little in front of the excretory pore.

The caudal end of the male is spirally coiled. The tail is 0.49 mm long according to Meyer, or  $\frac{1}{52}$  of the total length [about 0.48 mm] according to v. Linstow. There are well-developed caudal alæ, which, according to Meyer, extend forward for a distance of 2.5 mm. from the tip of the tail. The cuticle of the ventral surface, according to this author, is longitudinally ribbed in the alar region. Both authors describe four pairs of preanal and two pairs of postanal papillæ, all of which, according to Meyer, have long and stout peduncles. One spicule, according to Meyer, measures 4.7–5.3 mm in length and is gradually tapering and pointed. The other is 1.8–2 mm long, and ends in a small knob. v. Linstow (who measured the spicules of a male which was only 11.8 mm. long, and therefore probably immature) gives their lengths as 3.74 mm. and 0.57 mm. respectively.

The tail of the female is blunt and measures about 0.33–0.38 mm. in length. The vulva, according to v. Linstow, is situated behind the middle of the body, dividing the total length in the ratio of 7 : 5. Meyer, however, finds it at 8 mm. from the anterior end, and describes it as a transverse slit. The vagina, according to this author, is 2.5 mm long, and is muscular. It is followed by a common uterine trunk which runs back somewhat sinuously and gives off two branches, one of which continues posteriorly, while the other returns anteriorly. v. Linstow states that the eggs, when immature, are elliptical and measure  $0.044 \times 0.026$  mm. When mature the eggs are thick-shelled and barrel-shaped, having (according to both describers) a hoop-like thickening near each pole. Meyer gives their dimensions as  $0.043 \times 0.023$ – $0.024$  mm, v. Linstow as  $0.047 \times 0.029$  mm.

#### 4. *Habronema bulbosum* (v. Linstow, 1906). (Fig. 39)

Synonyms :—*Physaloptera bulbosa* v. Linstow, 1906; *Cyrnea bulbosa* Ortlepp, 1925; *Habronema bulbosa* Maplestone, 1932.

Hosts :—This species was originally recorded from the stomach of *Paro spicifer*. Ortlepp (1925, a) records it from under the lining of the gizzard of the common peafowl (*Paro cristatus*)

and Burmese peafowl (*P. muticus*), and has given a fuller description. Maplestone (1932, *b*) also records it from the last-mentioned host in the Zoological Gardens, Calcutta.

According to v. Linstow's description, the male measures 18.1 mm in length and 0.1 mm in thickness, the female 27.8 mm and 0.51 mm respectively. Ortlepp's specimens were smaller, the male measuring up to 10.4 mm in length and 0.325 mm. in thickness, the female up to 24 mm and 0.455 mm. The

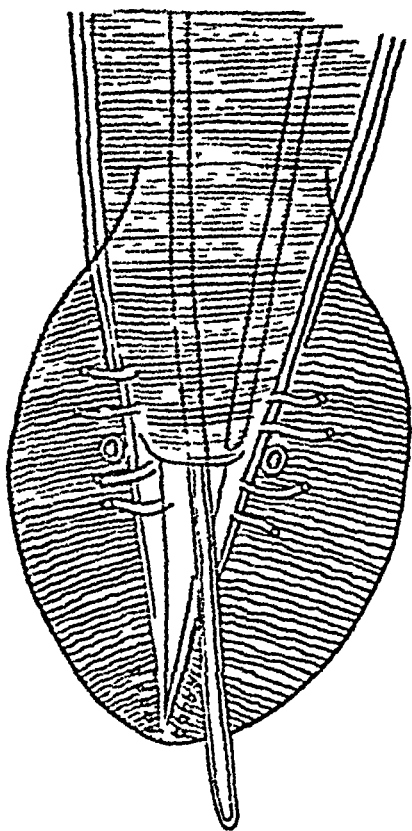


Fig. 39 — *Habronema bullorum*. Posterior end of male, ventral view (After v. Linstow.)

cuticle has fine transverse striations. The anterior end is rounded. According to v. Linstow there are six lips; according to Ortlepp two lateral lips, each with "a large median lobe and two smaller lateral lobes." According to Maplestone, however, the lateral lips are typical and there are "small dorsal and ventral cuticular 'lips'." The pharynx is about one and a half times as long as broad, its length being apparently

between 0.04 and 0.05 mm. Its wall is strongly chitinated and gradually thickened posteriorly. The oesophagus occupies, according to v. Linstow,  $1/7-1/5$  of the total length, but according to Ortlepp only about  $1/10$ . Its anterior portion is about  $1/10$  of the whole. The nerve-ring is in its posterior third, or at 0.35 mm from the anterior end according to v. Linstow. The cervical papillæ are situated at the level of the nerve-ring or just in front of it, and are small and spine-like.

The caudal end of the male is bent ventrally, and has short and broad alæ which form an oval bursa-like structure. The tail, according to v. Linstow, is  $1/46$  of the total length [0.4 mm]. From Ortlepp's figure it appears to be a little more than 0.3 mm long. The ventral surface immediately in front of the cloacal aperture is covered with irregularly-arranged tubercles. There are from five to seven pairs of fairly large, shortly pedunculate papillæ in the cloacal region, three or four pairs being preanal. One pair in front of the cloacal aperture and one pair behind it are nearer to the mid-ventral line than the others. Near the tip of the tail there are four or five pairs of very small lateral papillæ. The spicules are tubular, the left measuring 2.17-2.45 mm in length and having a fairly sharp point, while the right is 0.88-0.945 mm long and has a blunt tip. The accessory piece has lateral wings which embrace the spicules.

The tail of the female is about 0.2 mm long, and is somewhat conical. The vulva is situated at about 1.25 mm from the posterior end. The vagina forms a thick-walled, muscular ovejector, about 0.55 mm long, into which the common trunk of the uterus opens ventrally and anteriorly. This portion of the uterus is about 0.6 mm long. The branches run forward parallel to each other, and their anterior limit, according to Ortlepp, is at about the middle of the oesophagus. From this point they run posteriorly again to the ovaries, which lie between the vulva and the posterior end of the body. The eggs are oval and thick-shelled, and measure  $0.042-0.044 \times 0.024-0.026$  mm.

##### 5 *Habronema indicum* Maplestone, 1929, *emend.* (Fig. 40)

Synonym — *Habronema indica* Maplestone, 1929, ? *Cyrnea coraci* Mirza and Basir, 1938 \*

Host — Indian roller (*Coracias benghalensis indica*); Zoological Gardens, Calcutta

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\* This species, from the gizzard of the same host in Hyderabad, appears very similar to *H. indicum*. The chief difference is in the arrangement of the caudal papillæ of the male, only two pairs being preanal. The left spicule is 0.81 mm long, the right 0.33 mm. The length of the male is 11 mm. The female is unknown.

The male, according to Maplestone (1929, *a*), measures 7.1 mm in length and 0.2 mm in maximum thickness, the female 10.75 mm and 0.35 mm respectively. Later (1930, *b*) Maplestone obtained further specimens which were "one or two millimetres longer in both sexes". The cuticle has fine transverse striations at intervals of about  $3\mu$ , and coarser striations about  $18\mu$  apart. The head has a diameter of 0.084 mm in the male and 0.19 [0.09] mm. in the female.

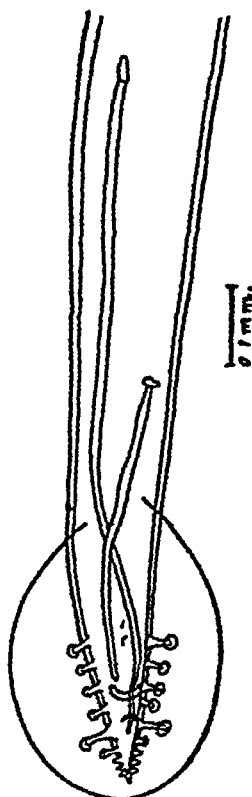


Fig. 40 —*Habronema indicum*. Posterior end of male; ventral view.  
(After Maplestone)

The lips are thick, and each bears large, pointed, subdorsal and subventral papillae. The pharynx is strongly chitinated, laterally compressed and widened rapidly in front in lateral view. Its anterior borders are serrated, forming four teeth on the inner surface of each lip, which interlock with those of the other side. The oesophagus is narrow. Its anterior and posterior portions, in the male, measure respectively 0.3 mm. and 1.1 mm. in length.

The caudal end of the male is straight. The alæ are broad and slightly asymmetrical, the left extending a little further forward than the right. They are united behind the tip of the tail, and their ventral surfaces are transversely striated. There are nine pairs of caudal papillæ, four pairs, with rather long peduncles, being preanal. One pair, with very long peduncles, is adanal or immediately postanal, and there are four more pairs, gradually diminishing in length, behind this. According to Maplestone's description of the single male available, the right spicule is nearly twice as long as the left, the two spicules measuring 0.694 mm and 0.357 mm respectively. The accessory piece is described as boat-shaped.

The tail of the female is 0.16 mm long, and has a blunt tip. The vulva is situated not far in front of the anus, at 0.59 mm from the posterior end. There is a flask-shaped muscular ovejector, measuring 0.175 mm in length. The common uterine trunk is relatively long (0.89 mm) and runs anteriorly. The uterine branches run forward parallel to each other to about the middle of the body, where one of them bends posteriorly. The eggs measure  $0.04\text{--}0.045 \times 0.02\text{--}0.026$  mm.

#### 6 *Habronema euplocami* Maplestone, 1930.

*Hosts* —Kali pheasant (*Gennæus* [*Euplocamus*] *leucomelanos*) and peacock-pheasant (*Polyplectron bicalcaratum*) (gizzard), Zoological Gardens, Calcutta.

Maplestone's (1930, b) original description was based on females only, from the first-mentioned host. Later (1932, b) he obtained specimens of both sexes from the second host, and gave a further description. The male measures 10.4 mm in length and 0.257 mm in maximum thickness, the female 18.5–19.5 mm and 0.34–0.44 mm respectively. Each lip has a quadrangular central portion and separate conical processes carrying the subdorsal and subventral papillæ. The central portion carries four longitudinal ridges on its inner surface, the two inner ridges projecting as teeth beyond the anterior border. The pharynx is strongly chitinized and is laterally compressed at its anterior end. It is 0.056 mm long in the female. The anterior portion of the œsophagus, in the female, measures 0.46 mm in length, the posterior portion 1.5 mm. The nerve ring (in the female) is situated at 0.35 mm, the anal excretory pore at 0.175 mm, from the anterior end. The cervical papillæ are placed far forward, in front of the middle of the pharynx.

The caudal alæ of the male are broad. They measure 0.336 mm in length, and extend just to the tip of the tail. The tail is 0.136 mm long. Maplestone states that there

are nine pairs of pedunculate papillæ, two pairs being preanal, one adanal and six postanal. His figure, however, appears to show a tenth pair of very small papillæ near the tip of the tail. The anterior five pairs of papillæ have alternately longer and shorter peduncles. The posterior four (or five) pairs are very small, and diminish in size posteriorly. The spicules are "thin and tapering" and measure respectively 1 mm and 0.436 mm in length. It is not stated which is the longer. The accessory piece is well developed and "appears trident-shaped when viewed from the ventral surface."

The tail of the female is 0.32-0.45 mm long. It ends in a blunt point, and has a pair of papillæ at about its posterior third. The vulva is situated at 1.45-1.6 mm from the posterior end. There is a thick-walled ojector, measuring 0.237 mm in length, from which the common uterine trunk runs forward for a distance of 0.396 mm. The uterine branches run forward to about the middle of the body, where one of them bends posteriorly. The eggs are thick-shelled and have "straight sides and rounded ends." They measure  $0.045 \times 0.021$  mm.

## 7. *Habronema imbricatum* Maplesone, 1930, *emend*

Synonym — *Habronema imbricata* Maplesone, 1930

Host — Scops owl (*Otus scops* [= *Scops pennatus*]) (gizzard). Zoological Gardens, Calcutta

The male measures about 8.3 mm in length and 0.23 mm in maximum thickness, the female 10.6 mm and 0.26 mm respectively. The cuticle has coarse transverse striations, which begin at a slight cuticular inflation at about the level of the anterior end of the pharynx and have sharply projecting edges, giving the body, in optical section, an imbricated appearance. The lips are trilobed, and on their internal surfaces are "supported by outwardly curving anterior extensions" of the pharynx. Each lip bears three pointed teeth. There are small, conical dorsal and ventral "lips." A short lateral ala is present on one side only, beginning at about 0.1 mm from the anterior end and extending posteriorly for a distance of about 1 mm. The pharynx is thick-walled and about 0.075 mm long. The oesophagus measures 2.78 mm in length in the male, and 2.5 mm in the female. In the former its anterior portion is 0.14 mm long, and its posterior portion 2.34 mm. The nerve ring, in the male, is situated at 0.24 mm, and the excretory pore at 0.3 mm, from the anterior end.

The male has broad caudal alæ which meet in a point beyond the tip of the tail. The tail is about 0.2 mm long. There are six pairs of caudal papillæ, four of which are preanal and two postanal. The anterior pair of postanal papillæ are

sessile, all the other papillæ pedunculate. The spicules measure 1·38 mm and 0·38 mm in length. The accessory piece is very small.

The tail of the female is 0·15 mm long, and ends in a sharp point. It bears a pair of small subventral papillæ at a little distance from the tip. The vulva is just behind the middle of the body, at 5·7 mm from the anterior end. The uterine branches are opposed. The eggs have thick shells, "with straight sides and rounded ends," and measure  $0·036 \times 0·015-0·016$  mm.

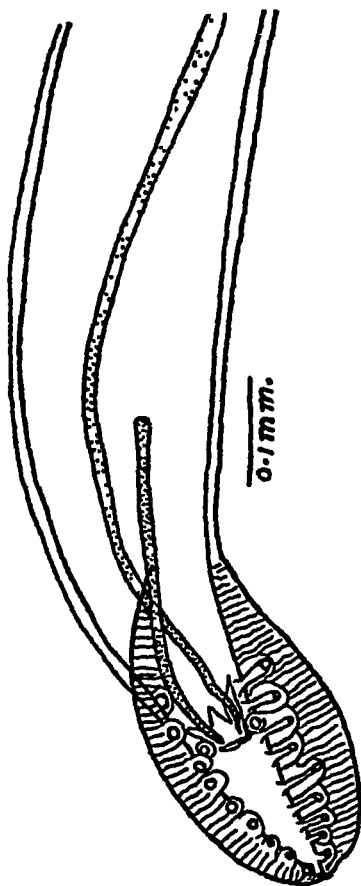


Fig 41.—*Habronema diesingi*. Posterior end of male, ventral view. (After Maplestone)

### 8 *Habronema diesingi* Maplestone, 1932 (Fig 41)

*Host* —Vulturine guinea-fowl (*Acryllium vulturinum*) (gizzard), Zoological Gardens, Calcutta.

Maplestone's description of this species is based on one male and one female. The male measures 8·8 mm. in length and

0.257 mm in maximum thickness, the female 1.45 mm and 0.336 mm respectively. Narrow lateral alae are present. Each lip has a quadrangular central lobe and two prominent outer lobes. These have prominently-projecting 'posterior angles and carry the submedian papillae. Dorsal and ventral shields are absent, but a pointed transverse process arises from the inner surface of each submedian lobe and overlaps that of the opposite lobe. The pharynx is stout and somewhat laterally compressed. Its length, including the depth of the buccal cavity, is 0.056 mm in the male and 0.068 mm in the female. The anterior portion of the oesophagus, in the female, is 0.356 mm long, and its posterior portion 2.344 mm. The nerve-ring is situated at 0.235 mm, the cervical papillae and excretory pore at 0.317 mm, from the anterior end.

The caudal alae of the male are well developed and extend just to the tip of the tail. The tail, from Maplestone's figure, appears to be about 0.15 mm long. There are ten pairs of caudal papillae. One pair, at the level of the cloacal aperture, are sessile, the rest (two pairs preanal and seven pairs postanal) are pedunculate. The spicules measure 1.7 mm and 0.297 mm in length. There is a broad accessory piece.

The tail of the female is 0.396 mm long, and is tapering and pointed. It carries a pair of papillae at 0.055 mm from the tip. The vulva is slightly prominent and is situated at 1.74 mm from the posterior end. The thick-walled ovejector describes almost a complete circle before turning forward to join the thinner-walled common uterine trunk. This "pursues an undulating course to a point about one millimetre anterior to the vulva," where it gives off the two branches. The ovaries are at opposite ends of the body. The eggs are thick-shelled and measure  $0.04 \times 0.024$  mm.

9 *Habronema magnilabiatum* Maplestone, 1932, *emend.*  
(Fig. 42)

Synonym — *Habronema magnilabiata* Maplestone, 1932, *Sicarius magnilabiata* Vaz, 1936

*Host*.—An Indian eagle (*Ichthyophaga nana plumbeus* [= *Polioælus plumbeus*]) (gizzard), Zoological Gardens, Calcutta.

The male measures 9.1 mm in length and 0.26 mm in maximum thickness, the female 15.6 mm and 0.39 mm respectively. A lateral ala is present on one side only, beginning at about 0.24 mm from the anterior end and extending posteriorly for a distance of about 1.3 mm. The lips are large, with a narrow base and a wide anterior portion, forming prominent dorsal and ventral angles. Large, rounded dorsal and ventral shields are present, each "partially divided by a longitudinal groove."

The pharynx is somewhat laterally compressed. Its length, in the male, is 0.028 mm. The anterior portion of the oesophagus is 0.396 mm long in both sexes, the posterior portion measures 2.63 mm in the male and 3.6 mm in the female. The nerve-ring, in the male, is situated at 0.297 mm, and the cervical papillæ at 0.198 mm, from the anterior end. The distance of the excretory pore from the same point is 0.327 mm in the male and 0.356 mm in the female.

The caudal end of the male is strongly curved ventrally, and is provided with relatively narrow alæ which extend to the tip of the tail. The ventral surface of the alæ, and of the body in the region immediately in front of the cloacal aperture, is longitudinally ridged. The tail, from Maplestone's figure, appears to be about 0.25 mm long. There are six pairs of caudal papillæ, four pairs being preanal and having long peduncles, while two pairs are postanal and sessile. The

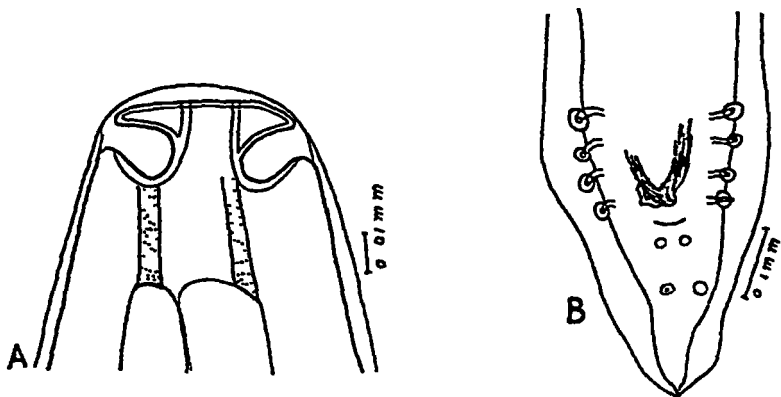


Fig 42—*Habronema magnilabiatum* A, anterior end, lateral view, B, posterior end of male, ventral view (After Maplestone)

spicules measure 1.78 mm and 0.554 mm in length, and both have simple points. There is a 'rugged,' asymmetrical accessory piece.

The tail of the female is 0.18 mm long, and tapers to a point. The vulva is situated in front of the middle of the body (at 8.1–8.5 mm from the posterior end). The eggs are thick-shelled and measure  $0.04 \times 0.03$  mm.

# 10 *Habronema asymmetricum* Maplestone, 1932, *emend* (Fig 43)

Synonym —*Habronema asymmetrica* Maplestone, 1932

Host —Pale harrier (*Circus macrourus*) (gizzard), Zoological Gardens, Calcutta.

The male measures 7.5 mm in length and 0.23 mm in maximum thickness, the female 11 mm and 0.29 mm respec-

tively A lateral ala is present on the left side only The lateral lips are broad, with a truncate anterior margin Each has a relatively small, crescentic central portion and large, conical outer portions The dorsal and ventral "lips" are small and conical The pharynx is somewhat laterally compressed, and its walls are thicker dorsally and ventrally than laterally According to Maplestone's description it is 0.18 mm long in the male and 0.22 mm in the female, but from his figures its length (excluding the buccal cavity) appears to be about 0.03 mm The anterior and posterior portions of the oesophagus measure 0.178 mm and 2.1 mm in length

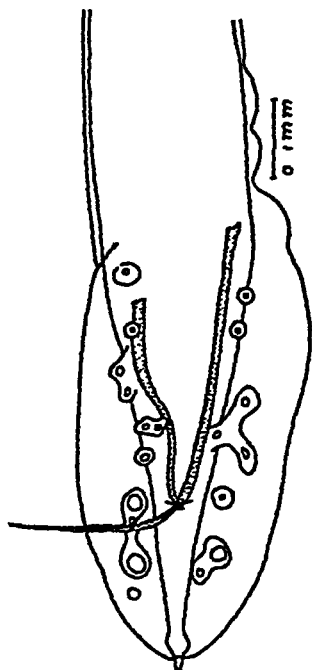


FIG 43—*Habronema asymmetricum*. Posterior end of male; ventral view (After Maplestone)

respectively in the male, and 0.29 mm and 4 mm in the female The nerve-ring and excretory pore are situated at 0.2 mm from the anterior end in the male, and at 0.28 mm in the female

The caudal alæ of the male are asymmetrical, the left being longer than the right "The ventral portion of the worm between the alæ, and the ventral surfaces of the alæ, are marked by longitudinal ridges interrupted by irregular transverse lines The caudal papillæ are quite irregularly placed, some being double, and as they differ in different specimens a detailed

description of their arrangement is of no value" Maplestone gives a figure (fig 43) showing eight papillæ or papillary terminations on the left side and eleven on the right. Five of these on the left and seven on the right are preanal, and one on each side adanal. The tail appears, from the figure, to be a little over 0.2 mm long, and its tip projects beyond the alæ. The spicules measure 0.65 mm and 0.24 mm in length. No accessory piece was seen.

The tail of the female is 0.198 mm long. The vulva is situated just in front of the middle of the body (at 5.9 mm from the posterior end). The eggs are thick-shelled and oval. Their size is not given.

### 11 *Habronema casuarii* Maplestone, 1932

*Host* —Double-wattled cassowary (*Casuarus bicarunculatus*) (gizzard), Zoological Gardens, Calcutta

This is a relatively large species, the male measuring 26.5 mm in length and 0.554 mm in maximum thickness, the female 53 mm and 0.89 mm respectively. There are marked annulations towards the posterior end of the body in both sexes. Each lateral lip has a broad central portion and outwardly-curved dorsal and ventral portions. The central portion bears four longitudinal ridges on its inner surface. The pharynx is cylindrical, and measures 0.1 mm. in length in the male and 0.15 mm in the female (from the figures, these measurements apparently include the depth of the buccal cavity). The anterior and posterior portions of the oesophagus measure about 0.7 mm and 8.3 mm in length respectively in the male, and 0.83 mm and 11.5 mm in the female. The excretory pore is situated at about 0.57 mm in the male, and 0.69 mm in the female, from the anterior end. In the former the distances of the nerve-ring and cervical papillæ from the same point are about 0.44 mm. and 0.5 mm respectively.

The caudal alæ of the male are broad and symmetrical, and are "strongly marked on their ventral surfaces by longitudinal and transverse grooves". The tail appears, from the figure, to be about 0.3 mm long. Its tip barely projects beyond the alæ. There are five pairs of large, lateral, pedunculate papillæ, of which three are preanal, one adanal and one postanal. Just behind the cloacal aperture there are two pairs of subventral, sessile papillæ, and there is a group of six or seven minute ventral papillæ close to the tip of the tail. The spicules measure 3.1–3.9 mm and 1–1.3 mm in length. The longer is more slender, and has a barb near the tip, the shorter has broad alæ and a simple, rounded tip. The accessory piece is stout and V-shaped.

The tail of the female is 0.39–0.44 mm long. The vulva is situated considerably behind the middle of the body, at 8.3–9.2 mm from the posterior end. The vagina runs forward from it for a distance of about 0.8 mm. The uterine branches are opposed, the anterior ovary extending forward as far as the junction of the two portions of the oesophagus, and the posterior almost to the anus. The eggs are oval and thick-shelled. Their dimensions are not given.

#### 4 Genus **DRASCHIA** Chitwood and Wehr, 1934

Synonym —? *Dermofilaria* Rivolta, 1884 (part)

Lips entire, without teeth, overlapped by dorsal and ventral cuticular shields. Paired lateral alæ present. Pharynx funnel-shaped, its wall formed of two separate lateral halves. Male with four pairs of pedunculate preanal papillæ and five pairs of postanal papillæ, of which the anterior pair is asymmetrical. Spicules unequal. A small accessory piece present. Vulva in front of the middle of the body. Female oviparous. Adult worms in the stomach-wall of Equidæ.

Genotype —*Draschia megastoma* (Rudolphi, 1819)

#### 1 *Draschia megastoma* (Rudolphi, 1819) Chitwood and Wehr, 1934 (Figs 44–47)

Synonyms —*Spiroptera megastoma* Rudolphi, 1819, *Spirura megastoma* Blanchard, 1849, *Filaria megastoma* Schneider, 1866, *Habronema megastoma* Seurat, 1914, ? *Dermofilaria irritans* Rivolta, 1884, ? *Filaria irritans* Railliet, 1885

*Hosts* —This is a parasite of the horse, donkey, mule and zebra. It occurs in nodules in the wall of the stomach, each nodule communicating by one or more openings with the lumen, and also in abscesses of the spleen. Its distribution is world-wide. In India it has been recorded from Madras, Hyderabad, the United Provinces, the Punjab and the North-west Frontier Province. Its presence has also been noted in Burma, and there are specimens in the British Museum (Natural History) from Ceylon.

The male measures 7–10 mm in length and up to 0.27 mm in maximum thickness, the female 10–13 mm and up to about 0.37 mm respectively. The head has a diameter of about 0.11 mm, and is separated by a transverse groove from the neck, which forms a "shoulder" of thickened cuticle. Each lip bears one of the lateral cephalic papillæ, while each of the dorsal and ventral shields carries two submedian papillæ. These have two terminations, an outer and an inner. The pharynx is about 0.13 mm long. The anterior portion of the oesophagus measures about 0.18 mm in length, the wider posterior

portion about 0.89 mm. The nerve-ring and cervical papillæ are situated just in front of the junction of the two parts of the œsophagus.

The caudal end of the male is closely coiled. The alæ and the ventral surface of the body in the alar region are longitudinally ribbed. The four pairs of preanal papillæ are arranged almost symmetrically. Of the five pairs of postanal

Fig 44

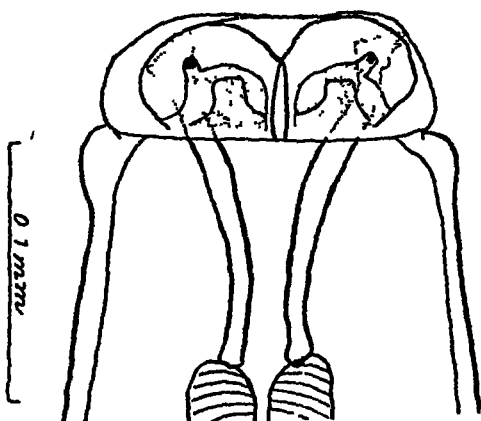


Fig 45.

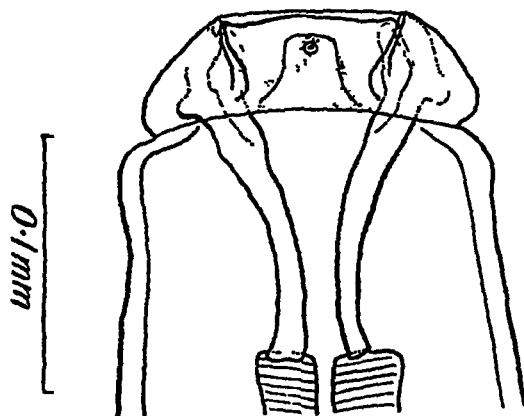


Fig 44 — *Draschna megastoma* Anterior end of female, dorsal view.  
(After Baylis and Daubney)

Fig 45 — *Draschna megastoma* Anterior end of female, lateral view  
(After Baylis and Daubney)

papillæ, the anterior is just behind the cloacal aperture, laterally placed and asymmetrical, the papilla of the right side being stout and extending almost to the mid-ventral line, while that of the left side is much smaller. The rest of the postanal papillæ are subventral, the three posterior pairs

forming a symmetrical group close to the tip of the tail. The left spicule is cylindrical and measures 0.46 mm. in length. The right spicule is 0.24 mm. long, and is flattened and grooved ventrally.

The tail of the female is bluntly conical and measures 0.28 mm. in length. The vulva is situated at about the anterior third of the body, and is surrounded by a small, raised, cuticular ring. There is a small muscular ojector, from which the muscular vagina runs posteriorly for a distance of about 0.8 mm. before giving off the uterine branches. These are muscular near their origin. One runs straight backward, the other doubles forward after running posteriorly for some

Fig 47

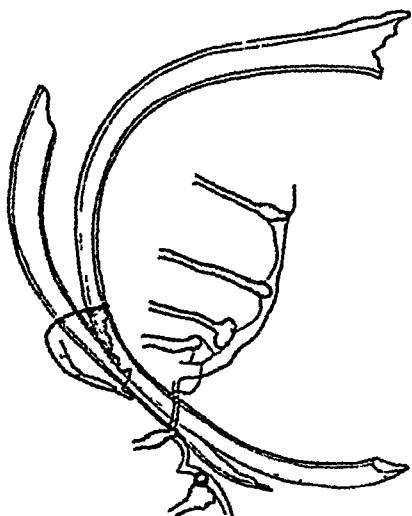
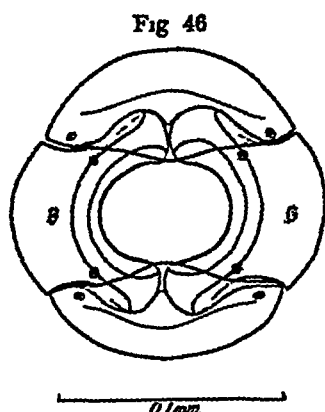


Fig 46—*Draschia megastoma*. Anterior extremity of female, viewed en face (After Baylis and Daubney)

Fig 47—*Draschia megastoma*. Cloacal region of male, lateral view, showing spicules, accessory piece and some of the papillae (After Baylis and Daubney)

distance. The eggs measure  $0.033-0.035 \times 0.008$  mm., and contain embryos *in utero*. According to Theiler (1923) the embryos may attain a length of 0.6-0.7 mm.

The life-history of this species, according to Hill (1918), Johnston and Bancroft (1920) and Roubaud and Descazeaux (1921), is very similar to that of *Habronema muscæ* and *H. microstoma*, and the intermediate hosts are Muscid flies of the same species as for *H. muscæ*, including the house-fly. The first-stage larvæ, however, enter the Malpighian tubules instead of the fat-body of the insect, and there cause the formation of nodules, within which they undergo a moult.

They later leave the Malpighian tubules and re-enter the body-cavity, where they moult again before migrating to the proboscis. If deposited on the lips of horses, they may reach the stomach and become adult. If deposited in the nostrils, they may enter the lungs and cause the formation of nodules in the bronchi, while if deposited in wounds of the skin they may play the same part as species of *Habronema* in producing "summer sores". In these cases they do not reach maturity. Crawford (1926) records the infection of a Drosophilid fly in Ceylon with larvæ which he believed to belong to *D. megastoma*.

## 5 Genus **PARABRONEMA** Baylis, 1921

Synonym —*Squamanema* van Thiel, 1925

Lips and dorsal and ventral cuticular shields resembling those of *Habronema*. Cuticle of head thickened and folded so as to form posteriorly a circlet of six horseshoe-shaped auricular appendages, of which two are lateral and four submedian. Pharynx elongate, cylindrical posteriorly. Tail of male with lateral alæ towards its tip, four pairs of preanal and two pairs of postanal papillæ, arranged somewhat asymmetrically, and a large, median, double precloacal papilla. Spicules markedly unequal. A small, triangular accessory piece present. Tail of female short and curved dorsally. Vulva near the posterior end of the œsophagus. Female viviparous or ovoviviparous. Adult worms in the stomach-wall of mammals.

Genotype —*Parabronema indicum* Baylis, 1921

### *Key to Species*

- |  |                        |
|--|------------------------|
| Longer spicule of male about 0.9 mm long, shorter spicule about 0.4 mm     | <i>indicum</i> , p. 92 |
| Longer spicule of male less than 0.6 mm long, shorter spicule about 0.2 mm | <i>smithi</i> , p. 95  |

### 1 *Parabronema indicum* Baylis, 1921 (Figs 48–50)

*Host* —Indian elephant (stomach-wall), Madras

The male measures up to 7.9 mm in length and 0.31 mm in maximum thickness, the female up to 13 mm and 0.39 mm respectively. The cuticular striations are at intervals of  $3.5\mu$ . The "head" is conical, being narrower in front than at the back of the auricular appendages, and measures 0.15–0.17 mm in length. Its diameter at the posterior end of the auricular appendages is 0.14–0.15 mm. The latter are regularly horseshoe-shaped and have narrow grooves on their free edges. The borders of the lips are simple. The pharynx is 0.17–0.18 mm long. The total length of the œsophagus

(measured from the anterior extremity) is 2.2–2.25 mm. The junction of its two portions is at about 0.4 mm from the head end. The nerve-ring is situated at 0.32–0.34 mm, the excretory pore at 0.33–0.35 mm, and the cervical papillae at 0.39–0.42 mm from the anterior extremity.

The tail of the male is 0.17 mm long. The six pairs of caudal papillae are all pedunculate. The peduncles of the anterior pair of postanal papillae lie transversely across the

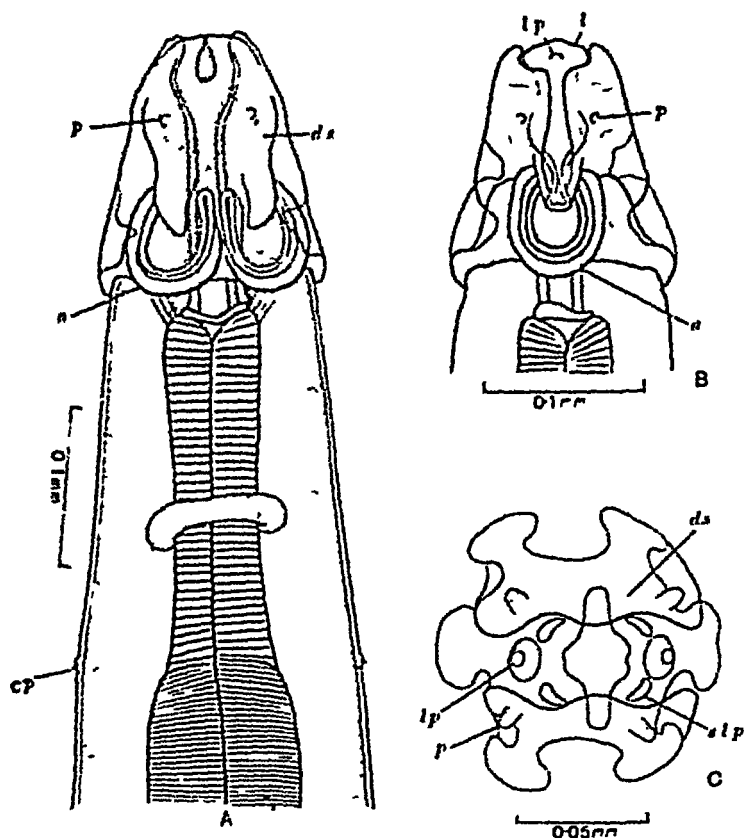


Fig 48—*Parabronema indicum*. Anterior end A, dorsal view, B, lateral view, C, viewed en face. *a, a*, auricular appendages, *cp*, cervical papilla, *ds*, dorsal shield, *l*, lip; *lp*, lateral papilla of lip, *p, p*, papillae of dorsal and ventral shields, *slp*, sublateral papilla of lip (After Baylis, in 'Parasitology')

ventral surface in such a way as to overlap, the termination of the papilla of the right side being considerably to the left of the middle line. The posterior pair are symmetrically placed. The two terminations of the median precloacal papilla are near

Fig 49

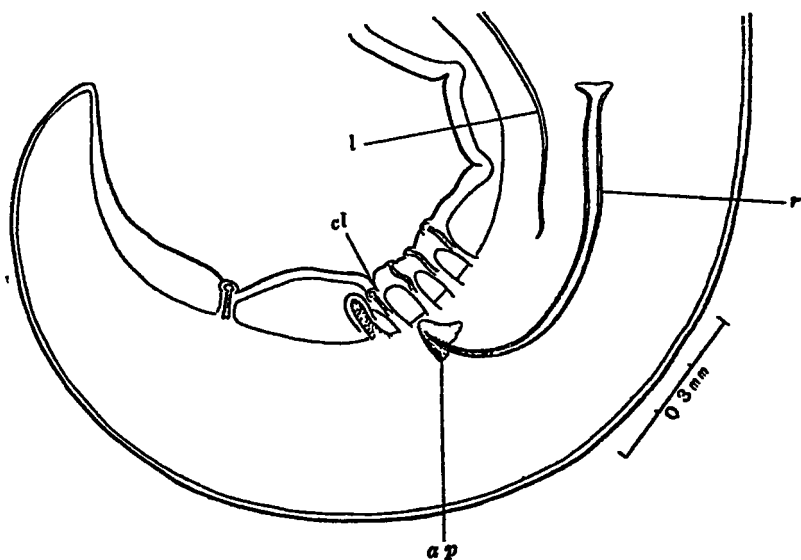


Fig 50

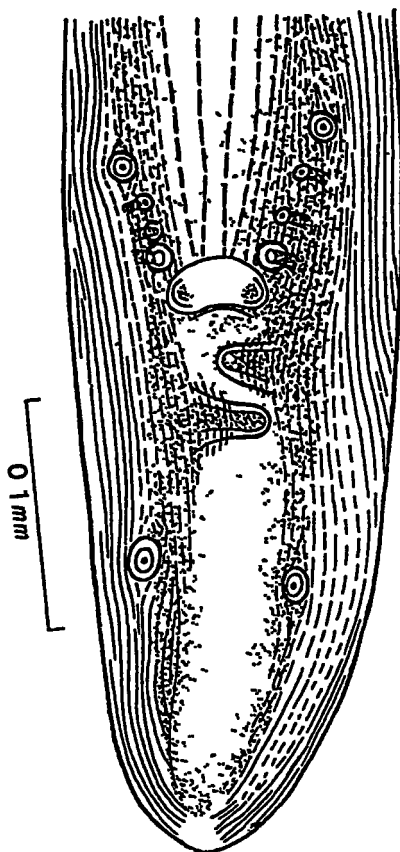


Fig 49 — *Parabronema indicum* Posterior end of male, lateral view  
*ap*, accessory piece, *l*, left spicule (terminal portion),  
*r*, right spicule (After Baylis, in 'Parasitology')  
 Fig 50 — *Parabronema indicum* Posterior end of male, ventral view  
 (After Baylis, in 'Parasitology')

its lateral limits. The left spicule is very slender, and measures 0.93 mm in length. The right spicule is stouter and 0.39 mm long. The length of the accessory piece is 0.06 mm.

The tail of the female is conical, with a rather blunt tip, and measures 0.32 mm in length. There is a pair of minute papillæ at 0.03 mm from the tip. The vulva is situated about 0.4 mm behind the posterior end of the œsophagus. The vagina forms a U-shaped bend at a distance of about 0.25 mm from the vulva. After a further course of about 0.4 mm it widens into a fusiform swelling which gives off the two uterine branches posteriorly. These also have small fusiform enlargements near their origin. One branch runs back to a point about 0.35 mm from the anus, where it turns forward again. The other turns forward anteriorly to this, and runs nearly as far as the posterior end of the œsophagus before forming a loop and running once more posteriorly. The embryos in the uterus are not enclosed in hard egg-shells.

## 2 *Parabronema smithi* (Cobbold, 1882) Baylis, 1921.

Synonyms —*Filaria smithi* Cobbold, 1882 [nec *Filaria smithi* Sambon, 1907], *Spiroptera smithi* Raillet, Henry and Bauche, 1914.

*Host* —Indian elephant (stomach-wall, in oval, flattened tumours of about the size of a filbert nut, each having an opening into the cavity of the stomach). This parasite was first recorded from a circus elephant, and very briefly described, by Cobbold. It was later found in Bengal by Mitter (1912), who added little to the description. Khalil (1922, b) has given a somewhat fuller account of it, based on material obtained in India.

The male measures 4.1–4.2 mm in length and 0.2 mm in maximum thickness, the female 8–8.5 mm and 0.25–0.26 mm respectively. The cuticle has very fine transverse striations. The "head" is 0.083 mm long, and has a diameter, at the posterior end of the auricular appendages, of 0.03 mm. The posterior margins of the appendages are nearly straight. The pharynx is 0.1 mm long. The anterior portion of the œsophagus measures 0.14–0.16 mm in length, the posterior portion 1.06–1.09 mm. The cervical papillæ are situated at about 0.21 mm, the nerve-ring at 0.22–0.23 mm, and the excretory pore at 0.25 mm (in the female) from the anterior extremity.

The tail of the male is 0.18 mm long, and has a rounded tip. The six pairs of caudal papillæ are all pedunculate. The left spicule measures 0.32–0.56 mm in length, the right spicule 0.18–0.21 mm. The length of the accessory piece is 0.03 mm.

The tail of the female is tapering, with a rounded tip, and measures 0.36 mm in length. The vulva is situated slightly in front of the posterior end of the œsophagus. The vagina forms a U-shaped bend at about 0.1 mm from the vulva. The ovarian tubes are mainly confined to the posterior half of the body. According to Cobbold, the eggs are "linear-oblong" and have an average length of 1/2000 of an inch. Khalil found no eggs, the uterus being packed with embryos.

### Subfamily ASCAROPSINÆ Alicata and McIntosh, 1933

Synonym — *Arduenninæ* Railliet and Henry, 1911

Lips not prominent, but trilobed. Dorsal and ventral cephalic shields absent. A pharynx or buccal capsule present, typically with spiral or annular thickenings in its walls. Asymmetry frequently present in the cervical and caudal alæ, and in the caudal papillæ and other structures of the male. Preanal papillæ of male four pairs. An accessory piece usually present.

#### Key to Genera

Anterior end of body with longitudinal rows of cuticular bosses . . . . .	[p 116.
Anterior end of body without cuticular bosses . . . . .	GONGYLONEMA,
1 Pharynx cup-shaped or funnel-shaped . . . . .	1
Pharynx cylindrical . . . . .	2
2 Pharynx contains six protrusible bicuspid or tricuspid teeth . . . . .	4
Six simple teeth or papillæ present within the opening of the mouth . . . . .	[p. 113
3. Male with four pairs of preanal papillæ . . . . .	CYLIOSPIRURA,
Male with seven pairs of preanal papillæ . . . . .	3
4 Pharynx spirally twisted . . . . .	SPIROCERCA, p 108
Pharynx straight . . . . .	CASTRONODUS, p 112.
5 A cervical ala present on left side only . . . . .	STREPTOPHARAGUS,
Paired lateral alæ present . . . . .	5 [p 101.
6 Three parallel alæ present on each side of body . . . . .	ASCAROPS, p 96
A single ala present on each side of body . . . . .	6
	[p 104
	PHYSOCEPHALUS,
	PHYSOCEPHALOIDES,
	[p 107

### 1 Genus ASCAROPS van Beneden, 1873

Synonym — *Arduenna* Railliet and Henry, 1911

Lips trilobed, each with a tooth projecting into the oral cavity. A cervical ala present on the left side only. Wall of pharynx with spiral thickenings. Male with asymmetrical caudal alæ. Cloacal aperture surrounded by a serrated cuticular thickening. Four pairs of pedunculate preanal papillæ and one pair of similar postanal papillæ present. Spicules

very unequal Accessory piece absent\* Vulva in front of the middle of the body Adult worms in the stomach of Sundaë

Genotype —*Ascarops strongylina* (Rudolphi, 1819)

### Key to Species

Male up to 15 mm, female up to 22 mm in length	<i>strongylina</i> , p 97.
Male up to 35 mm, female up to 55 mm in length	<i>dentata</i> , p 99

### 1 *Ascarops strongylina* (Rudolphi, 1819) Alicata and McIntosh 1933 (Figs 51 & 52)

Synonyms —*Spiroptera strongylina* Rudolphi, 1819, *Spiroptera strongyliformis* de Blainville, 1828, *Filaria strongylina* Schneider, 1866, *Arduenna strongylina* Raillet and Henry, 1911, *Habronema strongylina* Ostertag, 1932

**Hosts** —This is a parasite of the stomach (and occasionally, of the small intestine) of the pig, wild boar and peccary, and has also been recorded from the ox in America. It occurs in almost all parts of the world. Maplestone (1930, a) records it from 25 out of 49 pigs examined in Calcutta, and there are specimens in the British Museum (Natural History) from a wild boar in Ceylon.

The following description is derived mainly from those given by Ciurea (1911, a), Raillet and Henry (1911, a) and Foster (1912). The male measures about 10–15 mm in length and 0.3–0.39 mm in maximum thickness, the female about 15–22 mm and 0.26–0.54 mm respectively. The body of the female is slightly constricted in the region of the vulva. The lateral ala begins at a point about 0.26–0.28 mm from the anterior extremity and extends to within about 2 mm of the posterior end of the body. Its maximum width is about 0.035 mm. The pharynx is about 0.07–0.1 mm long and 0.03–0.035 mm wide. Its wall, according to Raillet and Henry, appears to be composed of several spiral ribbons (two or three in the male, four or five in the female), and thus resembles a screw with multiple threads. The oesophagus is about 3.1–3.9 mm long. The nerve-ring is situated at about 0.35 mm, and the excretory pore at about 0.48 mm, from the anterior end. The cervical papillae are asymmetrically placed, that of the left side being at about 0.19 mm and that of the right at about 0.39 mm from the anterior extremity.

The tail of the male is 0.15–0.2 mm long. The caudal ala of the right side is about twice as wide as that of the left.

\* According to Chen (1927) an accessory piece is present in *A. dentata*.

There are four pairs of papillæ, with long peduncles, which are mainly preanal in position, but of which the posterior two may be adanal or postanal. Those of the right side usually form a regular series, while those of the left show some irregularity of arrangement. In addition to these there is another pair of pedunculate papillæ at about the middle of the tail. Immediately behind this Yorke and Maplestone (1926) figure two pairs, and Maplestone (1930, *a*) three pairs, of small sub-ventral papillæ, while in both figures an isolated pair is shown near the tip of the tail. Ciurea found five pairs of these small

Fig 52

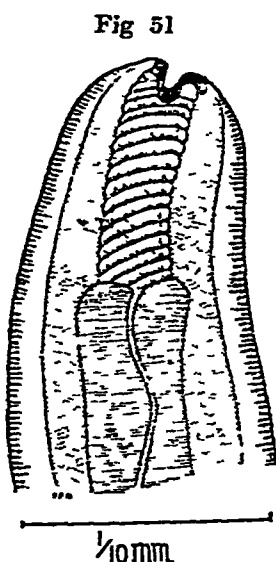


Fig 51

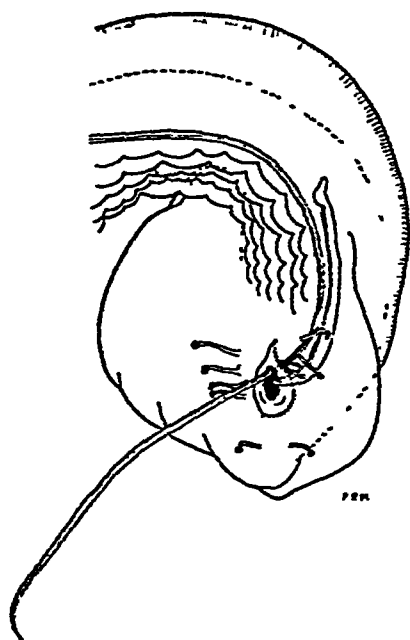


Fig. 51.—*Ascarops strongylina* Anterior end  
(From Baylis, after Foster.)

Fig 52 —*Ascarops strongylina* Posterior end of male ;  
ventral view. (From Baylis, after Foster )

papillæ. The left spicule is slender and finely pointed, and measures 2.24–2.9 mm. (or, according to Chen (1936), 1.3 mm) in length. The right spicule is stouter and blunter, and is about 0.45–0.62 mm. long.

The tail of the female is bluntly conical and measures about 0.21–0.27 mm in length. The vulva is situated at 7–8 mm from the anterior end of the body, and is displaced towards the left side, opening just ventrally to the lateral ala. The vagina at first runs transversely round the body, between the cuticle and the muscular layer of the body-wall, and then

posteriorly within the body-cavity. It is about 1.7 mm long. The uterine branches are opposed at their origin. The posterior branch doubles forward at a distance of about 3.6 mm from its origin, and its ovary is situated in the oesophageal region. The anterior branch doubles back at a similar distance from its origin, and its ovary lies in the posterior region of the body. The eggs are oval, with thick shells, slightly flattened and operculate at the poles, and covered by a thin, irregular membrane. They measure  $0.034-0.039 \times 0.018-0.02$  mm, or, according to Alicata (1935),  $0.041-0.045 \times 0.022-0.026$  mm. Alicata states that the shell shows 'numerous small punctations'.

The intermediate hosts of this species are coprophagous beetles of various genera (*Onthophagus*, *Aphodius*, *Gymnopterus*, *Scarabæus* and others). A dragonfly (*Anax parthenope*) has also been recorded as a host by Ono (1932), while the third-stage larvæ may occur encapsulated in various small mammals, birds and reptiles.

## 2 *Ascarops dentata* (v. Linstow, 1904) Alicata and McIntosh, 1933 (Fig 53)

Synonyms—*Spiroptera dentata* v. Linstow, 1904, *Arduenna dentata* Railliet and Henry, 1911.

*Hosts*—This species was originally recorded from the stomach of a wild boar (*Sus cristatus*) at Chilaw, Ceylon. It has also been recorded from the domestic pig in Annam by Railliet and Henry (1911, a) and in Canton, China, by Chen (1936, 1937), and from *Sus barbatus* in Borneo by Baylis (1926). v. Linstow's original specimens do not appear to be available in the Colombo Museum. His description has been considerably amplified by Chen (1937).

The male measures 25–35 mm in length and 0.7–0.8 mm in maximum thickness, the female 40–55 mm and 1–1.2 mm respectively. The cuticle is finely striated. The pharynx, according to v. Linstow, is 0.11 mm long, and its entrance is armed with a dorsal and a ventral tooth. According to Chen its length is 0.086–0.182 mm and its width 0.04–0.05 mm. The anterior portion of the oesophagus, according to this author, measures 0.43–0.49 mm in length, and the posterior portion about 4.1–5.3 mm. The nerve-ring is situated at about 0.46–0.49 mm (according to v. Linstow 2.64 mm), and the excretory pore at 0.59 mm, from the anterior extremity. The cervical ala begins at about the level of the nerve-ring, and has a maximum width of 0.03–0.04 mm. The left cervical papilla is situated at 0.3–0.32 mm, the right at 0.66–0.7 mm from the anterior end.

The caudal end of the male resembles that of *A. strongylina*. Its ventral surface and that of the caudal alæ are covered with longitudinal rows of elongate or scale-like cuticular thickenings. The tail is about 0.5 mm long. The right ala is longer and narrower than the left. There are five pairs of papillæ with long peduncles, four pairs being preanal and asymmetrical, and one pair postanal. Between the latter and the tip of the tail Chen finds five pairs of small, sessile, subventral papillæ. The spicules, according to v Linstow, measure 0.92 mm and 0.35 mm in length respectively. Railliet and Henry, however, give their lengths as 3.75–4.225 mm and 0.54–0.65 mm, and Chen as 4.1 mm (left) and 0.6 mm (right).

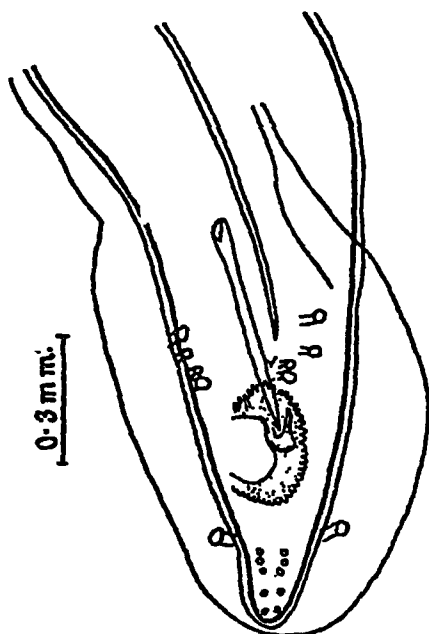


Fig 53 —*Ascarops dentata*. Posterior end of male, ventral view (After Chen, in 'Parasitology')

The tail of the female is short, conical and curved dorsally, according to v Linstow. According to Chen it is straight, bluntly conical and 0.58 mm long. The vulva, according to v Linstow, is "placed far behind the middle, and divides the body in the proportion of 70:23". Railliet and Henry, however, state that it is situated at the anterior three-eighths of the body, and Chen that it is in the anterior two-fifths. The eggs are cylindrical and thick-shelled, and measure  $0.039 \times 0.017$  mm according to v Linstow, or  $0.036 \times 0.022$  mm. according to Chen.

2 Genus **STREPTOPHARAGUS** Blanc, 1912

Lips trilobed, greatly reduced. A single cervical ala may be present on the left side. Within the hexagonal opening of the mouth there are six teeth, which may be simple or complex, and two additional teeth, dorsal and ventral, at the anterior end of the pharynx. The latter is elongate and forms a half-turn of a spiral in its course. Its walls show irregular transverse ridges. Caudal end of male spirally coiled, with broad alae. Four pairs of preanal and one pair of postanal pedunculate papillae present. Cloacal aperture sometimes partly surrounded by a fringe of claw-like cuticular processes. Spicules very unequal and dissimilar. A small accessory piece present. Vulva in front of the middle of the body. Adult worms in the stomach or intestine of mammals.

Genotype — *Streptopharagus pigmentatus* (v. Linstow, 1897)

1 *Streptopharagus pigmentatus* (v. Linstow, 1897) Railliet and Henry, 1918 (Figs 54-57)

Synonyms. — *Spiroptera pigmentata* v. Linstow, 1897, *Streptopharagus armatus* Blanc, 1912; *Streptopharagus intermedius* Ortlepp, 1925, *Streptopharagus magnus* Maplestone, 1929

*Hosts* — This species was originally recorded by v. Linstow from the small intestine of *Cercopithecus albogularis*. The material recorded by Maplestone (1929, *d*), under the name of *S. magnus*, was obtained from the stomach and intestine of a hoolock gibbon (*Hylobates hoolock*) in the Zoological Gardens, Calcutta. There has been much confusion among the species of the genus *Streptopharagus*, and forms from a number of Asiatic and African monkeys have been described as distinct. Sandground (1933), however, has pointed out that several of these grade into each other in such a way that they probably represent only a single, somewhat variable species. He does not mention *S. magnus* Maplestone, but it has been included in the synonymy given above because it does not appear to possess any satisfactory distinguishing characters.

The male measures 28-55 mm in length and 0.6-1 mm in maximum thickness, the female 46-95 mm and 0.85-1.5 mm, respectively. The cuticular striations are at intervals of 10-20  $\mu$ . The cuticle immediately behind the head is slightly inflated. A lateral ala is present in the oesophageal region on the left side only. It has a width of about 0.05 mm. The teeth are simple. The pharynx is about 0.3-0.6 mm long. The total length of the oesophagus, measured from the anterior extremity, is 6.8-12 mm., and that of its anterior portion, also measured from the anterior end, 0.9-1.35 mm. The nerve-ring is situated at 0.55-0.65 mm from the anterior end in the male, and at 0.66-0.9 mm in the female. The cervical

papillæ, which have bristle-like terminations, are asymmetrically placed, that of the left side being usually just behind the pharynx (at 0.25–0.45 mm from the anterior end), while that of the right side is behind the nerve-ring (at 0.61–0.8 mm from the anterior end). The excretory pore is at about the level of the right cervical papilla.

Fig 54

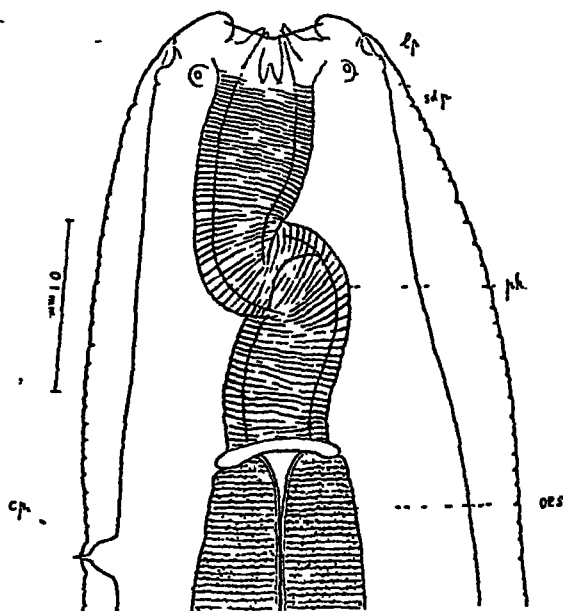


Fig 56

Fig 55

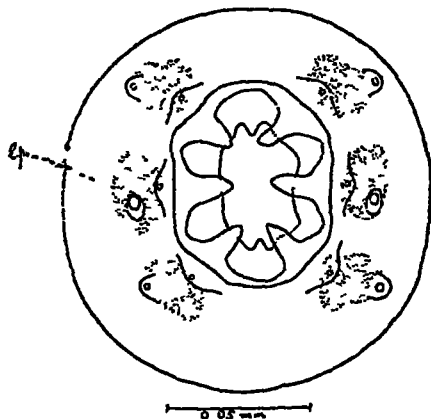
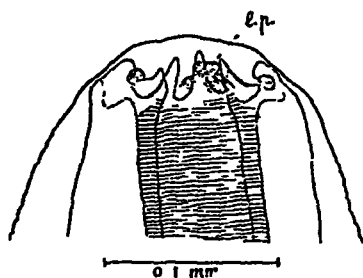


Fig 54 —*Streptopharagus pigmentatus* Anterior end of female, dorsal view *cp*, cervical papilla, *lp*, lateral cephalic papilla; *oes*, oesophagus, *ph*, pharynx, *sdp*, subdorsal papilla (After Baylis)

Fig 55 —*Streptopharagus pigmentatus* Anterior end of female, lateral view *lp*, lateral papilla (After Baylis)

Fig 56 —*Streptopharagus pigmentatus* Anterior extremity of female, viewed en face *lp*, lateral papilla (After Baylis)

The caudal alæ of the male are transversely striated on their dorsal surface and tessellated, as is the portion of the body between them, ventrally. The tail measures about 0.4–0.5 mm in length. On the left side of the tail, towards the mid-ventral line, and extending across the body in front of the cloacal aperture, there is a series of more or less prominent, claw-like cuticular structures with hooked tips\*. The four pairs of preanal papillæ have long peduncles. The two posterior papillæ of the series on each side are close together and separated by a space from the other two, which are

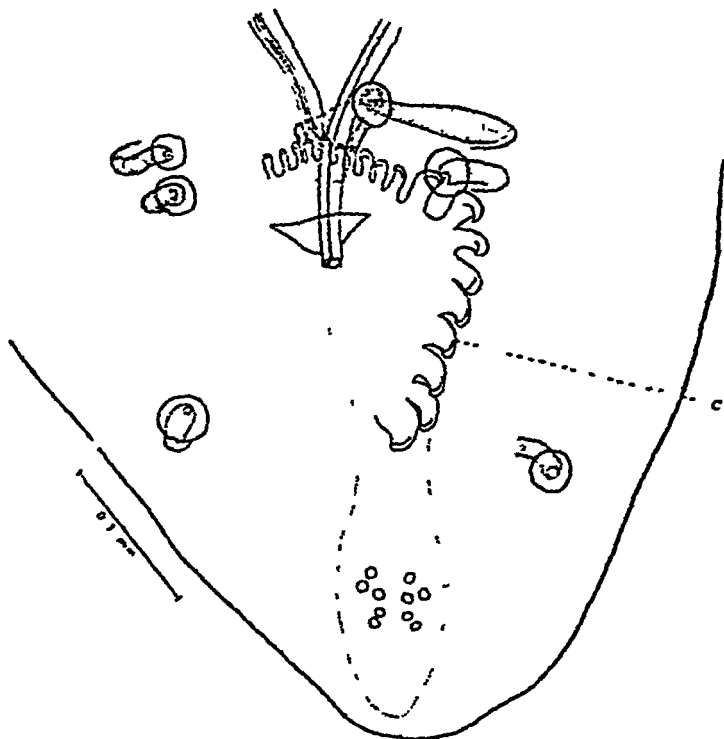


Fig 57—*Streptopharagus pigmentatus* Posterior end of male, ventral view, c, claw-like structures. Left spicule (protruding from cloaca) broken off. (After Baylis.)

also close together. The peduncles on the left side are longer and stouter than those on the right. v. Linstow figured a pair of sessile papillæ just in front of the cloacal aperture,

\* These structures represent, no doubt, a special local development of the tessellated pattern of the general surface of this region. They appear to vary in degree of development—Ortlepp (1925, b) failed to find them in the forms identified by him as *S. armatus*, *S. pigmentatus* and *S. intermedius*—but are so pronounced in some specimens that Sandground's (1933) description of the appearance of "claw-like structures" as a "delusion" seems scarcely justified.

but other authors have not confirmed their presence. There is a pair of lateral, pedunculate papillæ at about the middle of the tail, and a group of five pairs of small, sessile papillæ near its tip. According to Ortlepp and Sandground there is also a pair of sessile subventral papillæ immediately behind the cloacal aperture. Both spicules are alate. The left spicule is slender and measures 4-6.7 mm in length, the right spicule is stouter and 0.5-0.76 mm long. The accessory piece is small and of an asymmetrical shape, its longer side being the left. Its length, according to different authors, varies between 0.033 mm and 0.078 mm.

The tail of the female is conical and measures 0.4-0.9 mm in length. The vulva, which is not prominent, is situated at 9.5-20 mm from the anterior end. The vagina is simple and muscular, beginning with a sharp U-shaped bend, or ovejector, and running posteriorly for a distance of about 3-9 mm. The uterine branches at first run posteriorly, parallel to each other, but one branch turns forward, and the ovaries are situated at the opposite ends of the body. The eggs are subcylindrical and measure  $0.03-0.042 \times 0.018-0.023$  mm. According to Maplestone their shells have an annular thickening near each pole.

### 3 Genus **PHYSOCEPHALUS** Diesing, 1861

Synonyms — *Cephalacanthus* Diesing, 1853 (part), *Mastophorus* Diesing, 1853 (part)

Lips trilobed, without teeth. Cuticle of anterior extremity inflated. Three parallel lateral alæ present on each side of the body. Pharynx relatively long, cylindrical, with spiral and annular thickenings in its wall. Male with narrow caudal alæ. Four pairs of pedunculate preanal papillæ present. Spicules unequal. An accessory piece present. Vulva behind the middle of the body. Adult worms in the stomach of mammals.

Genotype — *Physocephalus sexalatus* (Molin, 1860)

#### 1 **Physocephalus sexalatus** (Molin, 1860) Diesing, 1861 (Figs 58 & 59)

Synonyms — *Trichina affinis* Diesing, 1851 (part), *Spiroptera strongylina sensu labrati* Molin, 1860, *Spiroptera sexalata* Molin, 1860, *Filaria strigis* v. Linstow, 1877, nec Gmelin, 1790, *Filaria strongylina* v. Linstow, 1879, nec Schneider, 1866, *Filaria sexalata* Perroncito, 1891, *Agammonema affine* v. Linstow, 1909, *Spiroptera (Filaria) strigis* Seurat, 1915, *Habronema sexalata* Ostertag, 1932, ? *Mastophorus globocaudatus* Diesing, 1853

*Hosts* — This species occurs in the stomach, and occasionally in the small intestine, of the pig, wild boar and peccary, and

has also been recorded from the horse, donkey, camel and ox. It has a wide geographical distribution. Maplestone (1930, a) records it from 26 out of 49 pigs examined in Calcutta. There are in the British Museum (Natural History) specimens obtained from a wild boar in Ceylon.

The following description is derived mainly from the accounts given by Cuerea (1912) and by Foster (1912). The descriptions by Raillet and Henry (1911, a), Seurat (1912) and Maplestone (1930, a) have also been consulted.

The male measures 6-15 mm in length and about 0.26-0.32 mm in maximum thickness, the female 9-22.5 mm and 0.33-0.48 mm respectively. The body of the female is

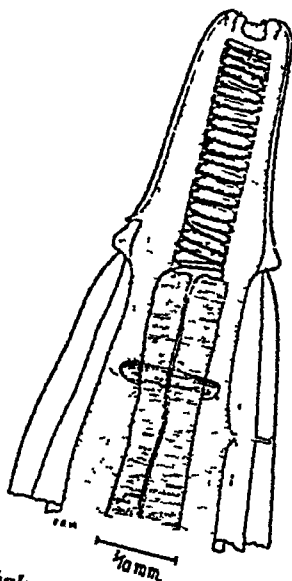


Fig 58—*Physocephalus acalatus* Anterior end, dorsal view  
(From Baylis, after Foster)

considerably narrowed at about the anterior third, and then gradually increases in thickness to a maximum near the posterior end. The cuticle is transversely striated. The cephalic cuticular inflation extends for a distance of 0.17-0.26 mm. The diameter at the anterior end is about 0.06 mm. At the posterior end of the cephalic inflation there are two prominent lateral pocket-like folds of cuticle. The lateral alae, three on each side, begin just behind these folds and extend to about the middle of the body in the male, and to about the anterior third in the female. The middle ala on each side is the widest, and has a maximum width of about 0.06 mm, while the others are about half as wide. Each

lobe of the trilobed lips bears a relatively large papilla. The median lobe of each lip is composed almost entirely of cuticle. The pharynx measures 0.23–0.32 mm in length and 0.053–0.057 mm in width. It has an internal spiral thickening of 21–25 turns, usually breaking up into separate rings in the middle. The oesophagus is about 2.7–3.5 mm. long. The nerve-ring is situated at about 0.43–0.44 mm from the anterior end. The excretory pore opens on the median ala of the right side, at 0.42–0.526 mm from the anterior end. There is apparently only a single cervical papilla, which is situated on

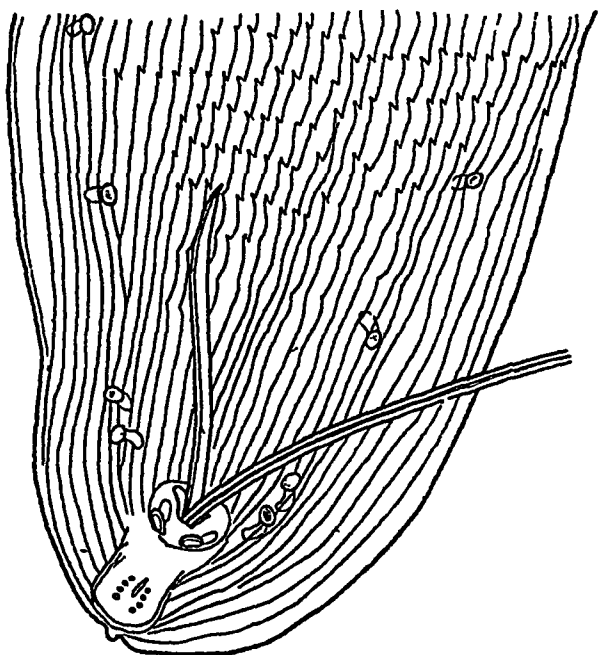


FIG 59 —*Physocephalus sexalatus* Posterior end of male, ventral view (After Ciurea)

the left side, a little in front of the posterior end of the cephalic inflation.

The caudal end of the male is coiled in a corkscrew-like spiral of two or three turns. The caudal alæ begin at about 1.4–1.5 mm from the posterior end, and are slightly asymmetrical, the right ala being a little longer than the left. The tip of the tail just projects beyond the alæ as a small spike. The cuticle of the ventral surface of the body in the preanal region, and of the ventral surface of the alæ, is thrown into longitudinal ridges, somewhat interrupted by transverse grooves, so that here and there they form claw-like projections. There are four pairs of sublateral preanal papillæ with long peduncles.

Two of these are close together and near the cloacal aperture, the other two placed at wider intervals. According to Ciurea there is a pair of similar papillæ near the middle line and close behind the cloacal aperture. Four pairs of small subventral papillæ form two regular series near the tip of the tail. Maplestone states that, in addition to these, "a little in front of the tip, where an angle is formed on each side by the sudden narrowing of the tail, there is a small sharp papilla." The spicules are alate and sharply pointed. The left spicule is very slender, grooved ventrally, and 1.23-2.5 mm long. The right spicule measures about 0.2-0.4 mm in length and is considerably stouter.

The tail of the female is about 0.12 mm long. It is suddenly constricted at about 0.04 mm from the anus, and its tip is bent ventrally and mucronate. The vulva is situated somewhat behind the middle of the body. In its neighbourhood there are, according to Ciurea, a number of small cuticular thickenings in the form of interrupted longitudinal ridges. The vagina runs posteriorly from the vulva, and the ovaries are situated at opposite ends of the body. The eggs are elliptical and slightly flattened at the poles, where there are faint indications of opercula\*. They measure  $0.031-0.039 \times 0.012-0.017$  mm, or, according to Alicata (1935),  $0.041-0.045 \times 0.022-0.026$  mm.

The intermediate hosts of *P. sexalatus* are coprophagous beetles of various genera (*Scarabæus*, *Gymnopleurus*, *Geotrupes*, *Onthophagus* and others). The third-stage larvæ may also be found encapsuled in various small vertebrates (amphibians, reptiles, birds and mammals) which have, presumably, fed upon the beetles. Infection of the final hosts could, apparently, take place through devouring any of these animals.

#### 4 Genus *PHYSOCEPHALOIDES* Maplestone, 1932

Maplestone states that the sole species of this genus (*P. primus*) "agrees with the genus *Physocephalus* in all particulars except that it has a single flange on either side of the body instead of three as in that genus." He considers it better to erect a new genus for it than to change the definition of *Physocephalus* to accommodate it. As may be seen from the following description, *P. primus* shows a remarkable agreement, even in most of its measurements, with *Physotephalus sexalatus*.

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\* According to Ciurea, there is a somewhat prominent button like thickening at one pole. Alicata (1935) states that this protuberance is conspicuous only in eggs that are not completely developed.

1. *Physocephaloides primus* Maplestone, 1932

*Host*.—Hoolock gibbon (*Hylobates hoolock*) (intestine); Zoological Gardens, Calcutta

The male measures 11.5–15 mm in length and 0.37–0.39 mm in maximum thickness, the female 18–21 mm and 0.4–0.42 mm respectively. The cephalic inflation is “overlapped posteriorly by the commencement of the lateral flanges”. The pharynx is 0.16–0.18 mm long, and the œsophagus about 4 mm, the anterior portion of the latter measuring about 0.5 mm. The nerve-ring is situated at 0.36–0.47 mm from the anterior end in the male, and at 0.5 mm in the female. The cervical papillæ are asymmetrical, one being short and stout, and situated near the posterior end of the cephalic inflation (at 0.18–0.26 mm from the anterior end), the other longer and more conical, and just behind the nerve-ring (at 0.44–0.54 mm from the extremity)\*

The caudal alæ of the male are relatively broad and symmetrical. The tail is 0.14 mm long. There are four pairs of pedunculate preanal papillæ, arranged as in *Physocephalus sexalatus*, and a group of about six small papillæ near the tip of the tail. The spicules measure 1.8–2.5 mm and 0.45–0.5 mm in length respectively, and both taper to sharp points. “There is a short but stout gubernaculum,” measuring 0.06 mm in length.

The tail of the female is 0.12 mm long, and is said to end in a short, blunt, “mucronate” tip, but is figured as quite bluntly rounded and curved ventrally. The vulva was observed only in one specimen, which was 21 mm long, and was situated at 5.2 mm from the posterior end. The eggs are thick-shelled and measure 0.028–0.03 × 0.012–0.014 mm.

5. Genus *SPIROCERCA* Railliet and Henry, 1911.

Lips trilobed, reduced. Within the hexagonal opening of the mouth there are six small papillæ. Pharynx short, thick-walled, somewhat expanded in front, but with its anterior border folded inwards. Caudal end of male spirally coiled and provided with narrow alæ. Four pairs of preanal and two pairs of postanal pedunculate papillæ present. Spicules very unequal. A small accessory piece present. Vulva in front of the middle of the body, near the posterior end of the œsophagus. Adult worms in tumours of the œsophagus or stomach of carnivorous mammals.

*Genotype*.—*Spirocerca lupi* (Rudolphi, 1809).

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\* The described position of this papilla is reminiscent of that of the excretory pore in *Physocephalus sexalatus*.

1 *Spirocerea lupi* (Rudolphi, 1809) Chitwood, 1933 (Figs 60-64)

Synonyms: —*Strongylus lupi* Rudolphi, 1809, *Spiroptera sanguinolenta* Rudolphi, 1819, *Filaria sanguinolenta* Schneider, 1866; *Spirocerea sanguinolenta* Railliet and Henri, 1911, *Spirura sanguinolenta* Seurat 1912

Hosts —This parasite was originally recorded from the wolf, but occurs also in the dog, jackal and fox, and is common in most warm countries. According to Gaiger (1915) it is very common in dogs in India. It has been recorded by

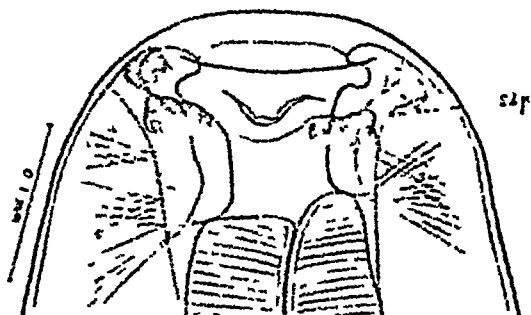


Fig 60 —*Spirocerea lupi* Anterior end of female, dorsal view  
a d p, subdorsal papilla (After Baylis)

several authors from the Punjab, United Provinces and Madras, and by v. Lanstow (1906, d) from Ceylon. The worms inhabit tumours, which may be as large as a walnut or even larger in the walls of the thoracic portion of the œsophagus, or

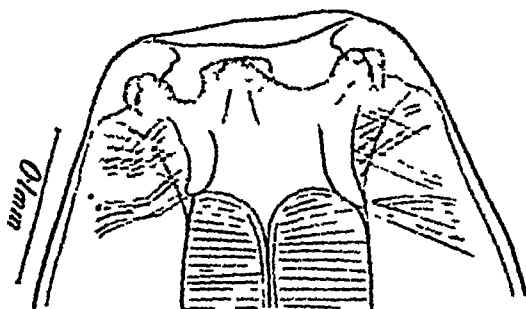


Fig 61 —*Spirocerea lupi* Anterior end of female, lateral view  
(After Baylis)

more rarely of the stomach, and also sometimes in the lymphatic glands, bronchi, thoracic and abdominal cavities, and in the wall of the aorta.

The male measures about 30-54 mm in length and up to 1 mm in thickness, the female about 54-80 mm and up to

1.5 mm respectively. The body is blood-red during life. The cuticular striations are at intervals of  $2.5-3\mu$ . The combined length of the buccal cavity and pharynx is about 0.09–0.1 mm. The width of the pharynx anteriorly is about equal to its length. It is slightly compressed laterally. The border of the mouth is surrounded by six masses of dense parenchyme which are the pulps of the cephalic papillæ. Two of these are situated laterally, two subdorsally and two subventrally. The lateral pulp-masses appear to have no external papillary terminations. The submedian pulp-masses are somewhat bilobed in shape, and their external terminations are situated on the lobes nearest to the lateral masses. Each

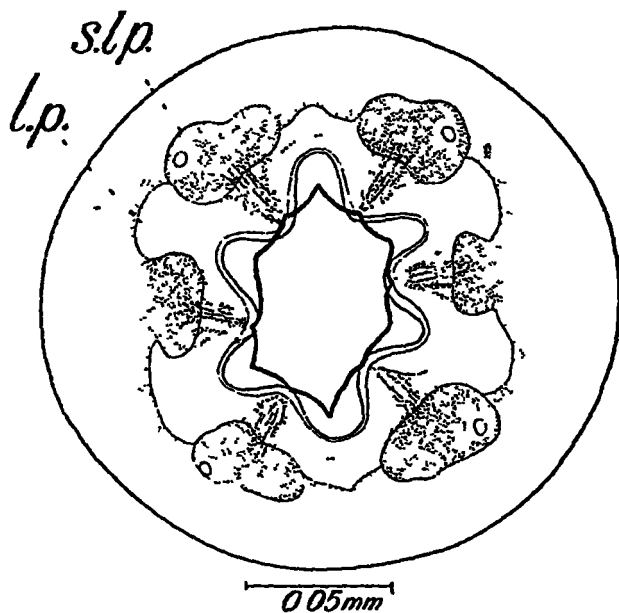


Fig 62—*Spirocerca lupi*. Anterior extremity of male, viewed *en face*. *l p*, lateral papilla, *s d p*, subdorsal papilla. (After Baylis.)

pulp-mass sends a branch inwards to a small subsidiary papilla situated just within the mouth-aperture. The total length of the oesophagus (measured from the anterior extremity) is about 5.8 mm in the male and 7 mm in the female. Its anterior portion, including the pharynx, measures 0.65–0.75 mm in length. The intestine is considerably narrower than the posterior portion of the oesophagus. The nerve-ring and cervical papillæ are situated at 0.5–0.6 mm from the anterior end, and the minute excretory pore (in the female) at 0.83 mm from the same point.

The two pairs of pedunculate postanal papillæ in the male are situated at about the middle of the tail, the posterior pair

being rather more lateral in position than the anterior. There is a large, median, precloacal papilla, and close to the tip of the tail there are five pairs of minute papillæ. The left spicule

Fig 63.

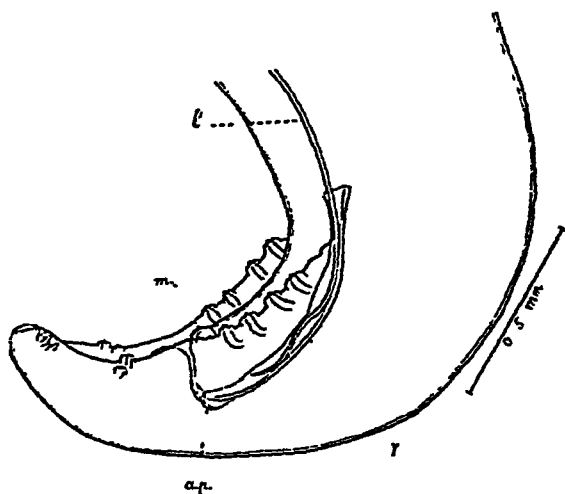


Fig 63.—*Spirocerca lupi*. Posterior end of male, lateral view. *a p*, accessory piece; *l*, left spicule, *m*, median preanal papilla, *r*, right spicule (After Baylis)

Fig 64

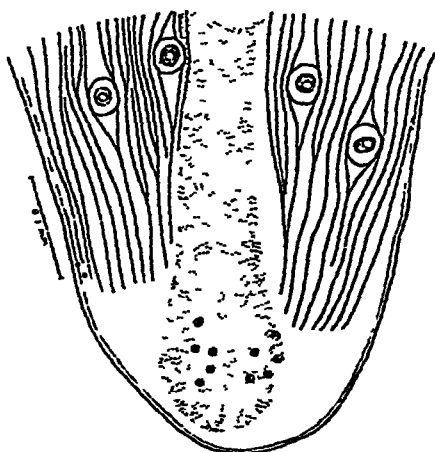


Fig 64.—*Spirocerca lupi*. Terminal portion of tail of male, ventral view. (After Baylis)

is slender and pointed, and measures about 2.45 mm in length. The right spicule is stouter and blunter, and has a length of

0.48–0.75 mm. The accessory piece is small and thin and appears horseshoe-shaped in ventral view.

The tail of the female is blunt, dorso-ventrally compressed and usually somewhat dorsally directed. It is 0.4–0.45 mm long, and bears a pair of almost terminal papillæ. The vulva is situated sometimes in front of, and sometimes behind, the posterior end of the œsophagus. The vagina runs forward from it at first, and has a sharp U-shaped "kink" at a distance of about 1.1 mm from it. It then turns posteriorly. The uterine branches are parallel. The eggs are cylindrical and thick-shelled, and measure about  $0.03\text{--}0.038 \times 0.011\text{--}0.015$  mm, or, according to Faust (1929, a),  $0.022\text{--}0.027 \times 0.008\text{--}0.012$  mm.

The intermediate hosts of this species are coprophagous beetles (species of *Scarabæus*, *Geotrupes*, *Gymnopleurus* and other genera). The third-stage larvæ may also become re-encapsuled in amphibians, reptiles, birds and small mammals which have fed upon the infested insects. If ingested by a dog or other suitable final host, the larvæ leave their cysts in the stomach and, passing through its wall, migrate either, according to Faust (1927), by way of the portal and pulmonary capillaries or, according to Hu and Hoepfl (1936), by direct penetration of the walls of the gastric and cœliac arteries, into the arterial system, where (especially in the thoracic aorta) the primary lesions occur. From the aorta some of the worms may penetrate into the wall of the œsophagus, and there give rise to the characteristic tumours, which acquire an opening into the lumen through which the eggs escape.

## 6 Genus *CASTRONODUS* Singh, 1931

Synonym.—*Gastronodus* Singh, 1934 (in reprint)

Closely resembles *Spirocerca*, but differs from that genus in the following characters.—Instead of six small papillæ within the opening of the mouth, there are six simple, conical, tooth-like processes. In the male there are seven pairs of preanal and three pairs of postanal pedunculate papillæ, and a pair of spine-like processes near the tip of the tail. A median precloacal papilla is absent. Adult worms in nodules in the stomach-wall of an insectivorous mammal.

Genotype.—*Castronodus strassenii* Singh, 1934.

### 1 *Castronodus strassenii* Singh, 1934

Synonym.—*Gastronodus strasseni* Singh, 1934 (in reprint)

Host.—Grey musk-shrew, known locally as the "musk-rat" (*Crocidura caurula*) (in nodules in the wall of the stomach); Hyderabad.

The male measures 16-26 mm in length and 0.3-0.56 mm. in maximum thickness, the female 25-40 mm and 0.4-1.15 mm respectively. The body is blood-red during life. The mouth is surrounded by six papillæ, each of which, from Singh's figure, appears to have an outer and an inner termination. At the entrance to the pharynx six simple, tooth-like processes project into the cavity of the mouth. The pharynx is 0.05 mm long. The œsophagus measures 2.6 mm in length, and has a short, narrow, muscular, anterior portion and a wide, glandular, posterior portion.

The caudal end of the male has slight alæ, the left ala being apparently somewhat longer and wider than the right. There are seven pairs of preanal and three pairs of postanal pedunculate papillæ. "Near the tip of the posterior end there are two spine-like processes." The left spicule measures 2.7 mm in length, the right spicule is stouter and 0.45 mm. long.

The vulva is situated in the œsophageal region, at 1.5 mm. from the anterior end.

#### 7 Genus CYLICOSPIRURA VEVERS, 1923

Lips greatly reduced. Opening of mouth circular, with six indentations. Pharynx cup-shaped or funnel-shaped, with six forwardly-directed, protrusible, bicuspid or tricuspid teeth springing from its walls. Other characters as in *Spirocerca*.

Genotype —*Cylicospirura subæqualis* (Moln, 1860).

#### 1 *Cylicospirura felinea* (Chandler, 1925) Sandground, 1933, *emend.* (Figs 65-67)

Synonyms —*Spirocerca subæqualis* Seurat, 1913, nec *Spiroptera subæqualis* Moln, 1860, *Spirocerca felineus* Chandler, 1925; *Cylicospirura subæqualis* Petrow, 1927, nec VEVERS, 1923.

*Hosts* —Chandler (1925, b) described this species from the domestic cat in Calcutta. It occurs in the stomach-wall, in tumours somewhat similar to those of *Spirocerca*. Sandground (1933) has pointed out that the forms described by Seurat (1913) from *Felis ocreata* in Algeria, and by himself from *Felis bengalensis* in Indo-China, agree with that described by Chandler in having tricuspid teeth, and differ from the *C. subæqualis* (Moln) of VEVERS (1923), which has bicuspid teeth. Although there is a very close agreement between the two species in almost all other respects, they are here provisionally treated as distinct.

The male measures 18-22.5 mm in length and 0.48-0.54 mm. in maximum thickness, the female 19-30 mm. and about

0.9 mm respectively. The colour of the body is blood-red during life. The cuticle has fine transverse striations and coarser annulations. There are no cervical alæ. The pharynx

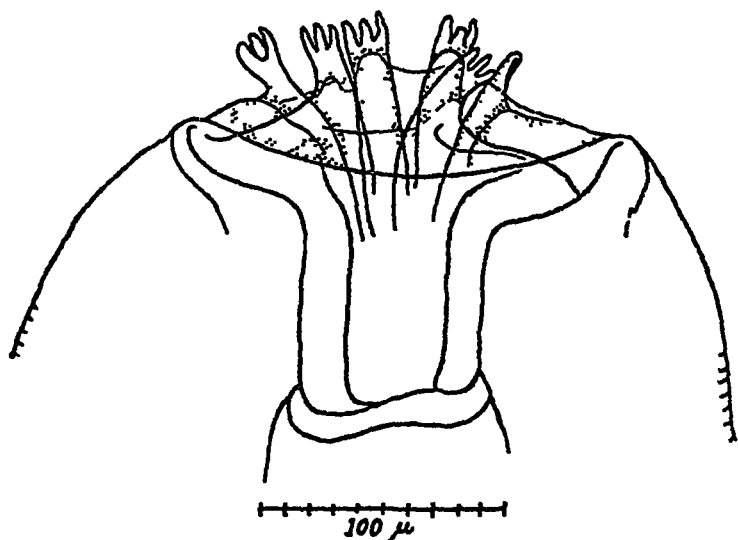


Fig 65.—*Cylicospirura felinea*. Anterior end (teeth extruded under pressure). (After Chandler)

is cup-shaped and very wide anteriorly, where its diameter in the female is 0.15 mm, but narrow posteriorly. Its length is about 0.1–0.14 mm. From its walls six longitudinal ridges

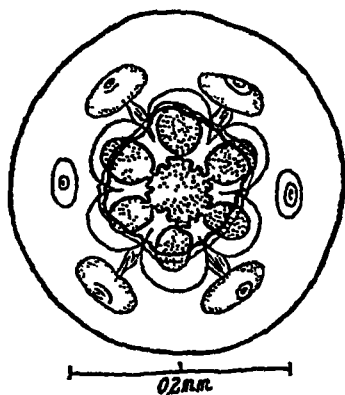


Fig 66.—*Cylicospirura felinea*. Anterior extremity, viewed en face. (After Sandground)

project into the cavity, each bearing on its summit a forwardly-directed tricuspid tooth. These teeth may be withdrawn into the pharynx or protruded through the mouth. The total length of the oesophagus is 4.2–4.5 mm in the male

and 4.6–5.3 mm in the female. It has a narrow anterior and a wide posterior portion. The nerve-ring is situated at about the middle of the former, or towards its posterior third.

The caudal end of the male is spirally coiled. The tail is about 0.26 mm. long, and ends in a blunt point. The alæ measure about 1 mm in length, and are longitudinally striated. The ventral surface of the body, between and in front of the alæ, is marked with scalloped ridges. There are four pairs of preanal papillæ with long peduncles. Chandler observed only one pair of postanal papillæ, but Seurat (1913) states that there are two pairs, both "inserted

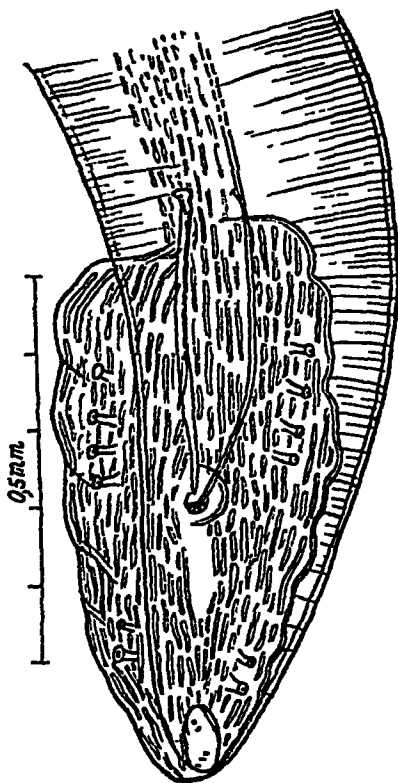


Fig. 67—*Cylcospirura felinea*. Posterior end of male, ventral view (After Sandground)

on the same line." Sandground (1933) also figures two pairs of pedunculate postanal papillæ, but these are situated one behind the other. According to Seurat there is a large

median precloacal papilla, and a group of eight minute papillæ at the tip of the tail. The latter are also figured by Sandground. The spicules measure respectively 2.25–2.5 mm. and 0.47–0.5 mm. in length. There is a small accessory piece, which, according to Chandler, is “comma-shaped” in lateral view.

The tail of the female is very bluntly rounded. Its length is 0.085 mm. according to Seurat, or about 0.2 mm. according to Chandler. The vulva is inconspicuous, and is situated at 3–5 mm. from the anterior end. According to Seurat there is a pyriform ovejector, with an elongate neck, into which the vagina opens obliquely. The ovejector has a very narrow lumen with a thick cuticular lining. Chandler describes the vagina as running forward at first from the vulva, at a distance of about 1 mm. from which it is enlarged to form a “sac-like bulb.” It then continues forward for a short distance as a thin-walled tube, and turns to run backward for about 2.5 mm. before giving off the two uterine branches. The eggs are thick-shelled and measure  $0.037 \times 0.016$ – $0.018$  mm.

## 8 Genus **GONGYLONEMA** Molin, 1857

Synonym — *Myzomimus* Stiles, 1892

Lips very small, forming a minute, funnel-like border surrounding the mouth. A short, narrow, cylindrical pharynx present. Body elongate and slender, its anterior portion with irregular longitudinal rows of cuticular bosses, at least on the left side. Paired cervical alæ present, or a single ala on the left side. Caudal end of male slightly twisted about its axis and provided with asymmetrical alæ and a variable number of pairs of pedunculate preanal and post-anal papillæ. Spicules very unequal and dissimilar. An accessory piece present. Vulva near the posterior end of the body. Vagina long. Uterine branches opposed. Adult worms in galleries in the mucous membrane of the œsophagus, mouth or stomach of mammals, or of the crop of birds.

Genotype — *Gongylonema minimum* Molin, 1857 \*

### *Key to Species*

Parasite of birds	<i>ingluvicola</i> , p. 122
Parasites of mammals	1
1. Cuticular bosses present on both sides of the body anteriorly, cervical alæ symmetrical	<i>pulchrum</i> , p. 117
Cuticular bosses present on left side only, cervical alæ asymmetrical	<i>verrucosum</i> , p. 120

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\* Possibly a synonym of *Filaria musculi* Rudolphi, 1819

1 *Gongylonema pulchrum* Molin, 1857. (Figs 68 & 69)

**Synonyms** —*Gongylonema spirale* Molin, 1857, *Filaria lalialis* Pane, 1864, *Spiroptera scutata oesophagea bovis* Müller, 1869; *Filaria scutata* Leuckart, 1873, *Spiroptera scutata* Korzil, 1878 [? 1877]; *Filaria scutata esophagea bovis* Perroncito, 1882; *Gongylonema scutatum* Raillet, 1892; *Myzomimus scutatus* Stiles, 1892, *Gongylonema confusum* Sonsino, 1896; *Gongylonema subtile* Alessandrini, 1914, *Gongylonema hominis* Stiles, 1921, *Gongylonema ransomi* Chapin, 1922; \**Spiroptera ursi* Dujardin, 1845, ? *Gongylonema filiforme* Molin, 1857, \* *Gongylonema contortum* Molin, 1860, ? *Gongylonema ursi* Neumann 1894

**Hosts** —This parasite occurs in a large variety of mammals including the pig, wild boar, sheep, goat, ox, zebu, buffalo, horse, donkey, camel, deer, chevrotain or mouse deer (*Tragulus* sp.), certain monkeys and man. It forms sinuous galleries in the thickness of the mucosa of the oesophagus, mouth and tongue, and sometimes of the rumen in ruminants. Its geographical range includes southern and eastern Europe, Asia, Africa, North America and Australia. Gaiger (1910; 1915) reported it to be very common in North India, the Punjab and the United Provinces, the hosts mentioned by him including the horse, ox, sheep, and a barking deer (*Cervulus muntjac*) from the Himalayas. Baylis and Daubney (1923, b) record the species from the ox (presumably *Bos indicus*), buffalo and urial sheep (*Ovis vignei*) in India. There are specimens in the British Museum (Natural History) from a goat from the Punjab.

The male measures 12–62 mm in length and about 0.15–0.36 mm in maximum thickness, the female 37–145 mm and about 0.2–0.5 mm respectively. The anterior end of the body is covered to a variable extent on both sides with cuticular bosses, arranged for the most part in two rather irregular longitudinal rows in each submedian field. The cervical alæ are symmetrical and relatively broad. They begin at 0.1–0.26 mm from the anterior end in the male, and at 0.19–0.3 mm in the female. The cuticular striations are at intervals of about 10–17.5  $\mu$ . The mouth is very small, and is surrounded by a somewhat funnel-shaped cuticular rim which is capable of a certain amount of retraction or protrusion. When protruded it measures about 0.02–0.03 mm. in diameter. It has two rather deep subdorsal and two similar subventral incisions. The cephalic papillæ are very minute and difficult to observe, but there are probably six of them immediately behind the buccal rim. The pharynx is narrow and tubular, and measures 0.04–0.08 mm in length. The oesophagus varies in length from about 3 to 9 mm. Its anterior, muscular portion is relatively short and narrow, and ends at about 0.4–0.78 mm.

from the anterior extremity in the male, and at 0.48–0.95 mm. in the female. The cervical papillæ are situated on cuticular prominences resembling the ordinary bosses, in front of the beginning of the alæ (at a distance of 0.075–0.22 mm. from the anterior end). The papillæ of the two sides are seldom quite symmetrically placed. The nerve-ring is somewhat in front of the middle of the anterior portion of the œsophagus, at a distance of about 0.25–0.4 mm. from the anterior end. The excretory pore is situated at about 0.3–0.9 mm. from

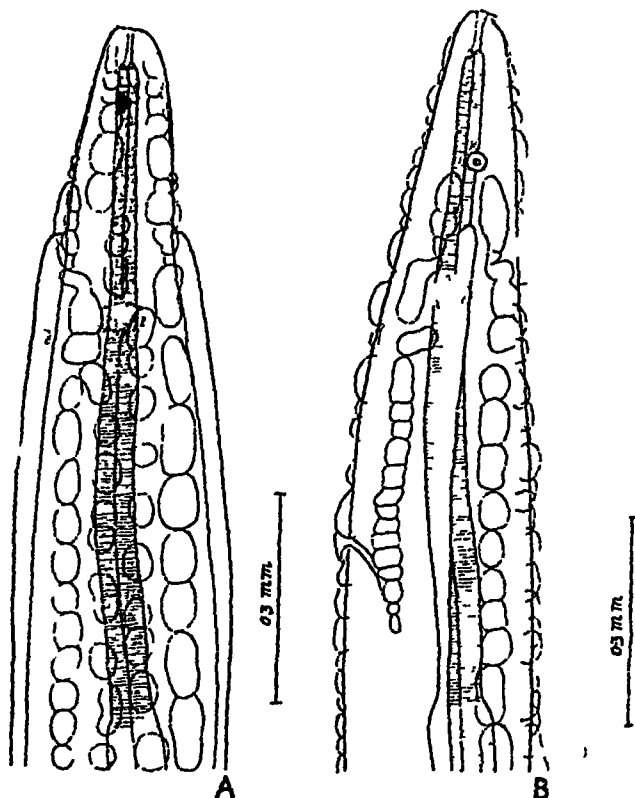


Fig. 68—*Gongylonema pulchrum*. Anterior end of female  
A, dorsal view, B, lateral view (After Baylis)

the same point, slightly in front of the junction of the two parts of the œsophagus.

The caudal alæ of the male are somewhat asymmetrical, the left ala extending further forward than the right, and being continued posteriorly round the tip of the tail. The length of the tail is 0.22–0.35 mm. The preanal papillæ have long peduncles, and are very variable in number and often asymmetrical. Most commonly there are five pairs, but there may be as few as two pairs, or as many as eight.

The postanal papillæ consist of four pairs of pedunculate papillæ and a group of about four pairs of very small, sessile papillæ near the tip of the tail, two of these being subventral and two lateral. The left spicule is long and slender, has a narrow, tubular shaft and narrow alæ, and ends in a blunt tip. It may vary in length from about 4 to 23 mm., and may, when very long, be nearly half the length of the worm. The right spicule is much stouter and broadly alate, and measures 0.084–0.18 mm. in length. The accessory piece is 0.07–0.12 mm. long, and has an anterior limb which forms a V with the right spicule, serving as a guide for the left spicule, and

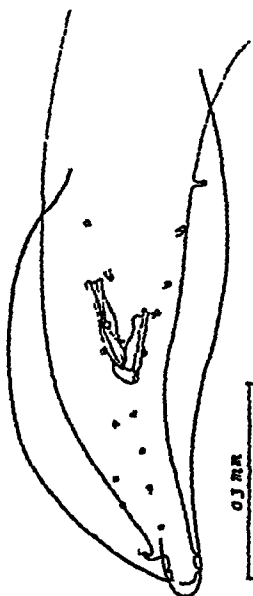


Fig. 69.—*Gongylonema pulchrum*. Posterior end of male, ventral view. (After Baylis.)

a posterior expansion at right angles to this limb, against which the right spicule rests.

The tail of the female is bluntly conical and about 0.19–0.38 mm. long. The vulva is slightly prominent, and is situated at a very variable distance (about 2–7 mm.) from the posterior end. The vagina runs forward from the vulva to near the middle of the body. The eggs are regularly oval, and have relatively very thick shells with faint indications of opercula at the poles. They measure 0.05–0.07 × 0.025–0.037 mm.

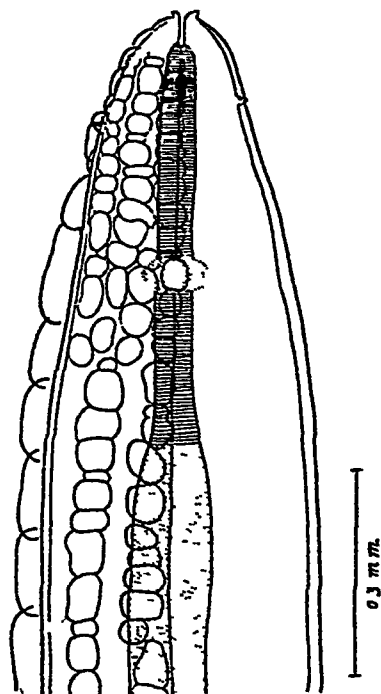
The intermediate hosts of this species include numerous dung-beetles of the genera *Aphodius*, *Onthophagus*, *Caccobius*

and others. The cockroach *Blattella germanica* has been found to be readily infected experimentally. The third-stage larvæ were found by the writer to emerge from the dead bodies of insects when these were placed in water, and to be able to live for some time in the water. The definitive hosts, however, probably acquire infection, in normal circumstances, by swallowing the intermediate hosts with their food.

**2 *Gongylonema verrucosum* (Giles, 1892) Neumann, 1894**  
(Figs 70 & 71)

**Synonyms.**—*Trichosomum verrucosum* Giles, 1892; *Spiroptera verrucosa* Giles, 1892, *nec* Mohr, 1860; *Gongylonema crenatum* Railliet, 1898

**Hosts.**—This worm was first recorded by Giles (1892, *b*) from the rumen of sheep at Shillong, Assam, and was also found by him later in the zebu (*Bos indicus*). There are



**Fig. 70**—*Gongylonema verrucosum*. Anterior end of female, dorsal view. (After Baylis)

specimens from this host from Bihar in the British Museum (Natural History). Bhalerao (1933, *a*) records the species from the "hill goat" or Himalayan ibex (*Capra sibirica*) at Muktesar, United Provinces. *G. verrucosum* also occurs in cattle, and possibly in goats, in South Africa, and has

been recorded from deer (*Odocoileus*) in North America. Giles' description of the worm was amplified by Neumann (1894), who examined the original material, and by the present writer (1925; 1926, a).

The male measures 32-41 mm in length and 0.25-0.3 mm in maximum thickness, the female 70-95 mm and 0.42-0.46 mm respectively. The cervical ala of the left side is well developed and begins at 0.175-0.25 mm from the anterior end. That of the right side is greatly reduced or absent. There are cuticular bosses in the anterior region on the left side only, ceasing abruptly at the mid-dorsal and mid-ventral lines. The cuticular striations are at intervals of 7.5-10  $\mu$ . The diameter of the buccal rim is about 0.025 mm. The

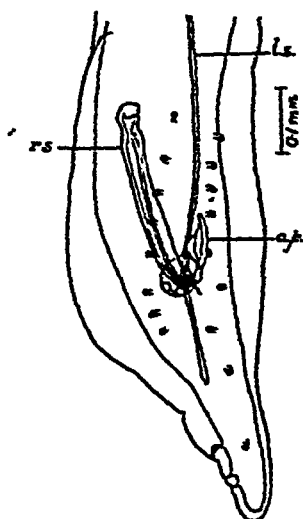


Fig 71—*Gongylonema verrucosum*. Posterior end of male; ventral view. *ap*, accessory piece, *ls*, left spicule, *rs*, right spicule (After Baylis)

pharynx is about 0.04-0.05 mm. long. The total length of the oesophagus, measured from the anterior extremity, is 6.5-8.5 mm in the male and 8.1-10 mm in the female. The length of its anterior portion, also measured from the anterior extremity, is 0.46-0.66 mm. The cervical papillae are situated at 0.13-0.2 mm from the anterior end, the right papilla being a little in front of the left, and the latter being on one of the cuticular bosses. The nerve-ring is at 0.25-0.35 mm, and the excretory pore at 0.41-0.6 mm, from the anterior extremity.

The tail of the male is 0.28-0.38 mm long. There are from five to eight preanal papillae on each side, those of the

two sides being frequently asymmetrical. There are usually four pairs of postanal papillæ, but occasionally there may be three or five papillæ on the right side and four on the left. The left spicule measures 9.5–10.5 mm in length, and is slender and provided with narrow alæ. The right spicule is 0.26–0.32 mm long, and is stout and of nearly uniform thickness, except for a slight constriction near the root. It has a broad ala on its inner side. The accessory piece measures 0.13–0.16 mm in length, and has a broad, flattened expansion on the median aspect posteriorly, in which the spicules slide.

The tail of the female is 0.3 mm long. It is suddenly constricted behind the anus and bent ventrally, and bears a pair of subterminal, subventral papillæ. The vulva is situated at a distance of 1.2–3.2 mm from the posterior end. The eggs measure 0.045–0.055  $\times$  0.025–0.032 mm.

### 3 *Gongylonema ingluvicola* Ransom, 1904

Synonym. — *Gongylonema sumani* Bhalerao, 1933

*Hosts* — This species occurs in the mucous membrane of the crop of the fowl, turkey and other gallinaceous birds. It was first recorded in the United States of America, and has since been found in various other parts of the world (Europe, Asia, Africa and Australia). Bhalerao (1933, c) has recorded a form which he named *G. sumani* from the fowl in India (Lucknow, United Provinces). In his book on the helminths of domestic animals in India (1935, b), however, *G. sumani* is not mentioned, but *G. ingluvicola* is recorded from fowls in Madras and the United Provinces. It is to be presumed that *G. sumani* is considered a synonym of *G. ingluvicola*, and there is little in the description to indicate that it is distinct.

The male measures about 14–22 mm. in length and 0.14–0.29 mm in maximum thickness, the female about 25–55 mm and 0.25–0.5 mm respectively. The cuticular striations are at intervals of 6–7  $\mu$  in the male and of 10–11  $\mu$  in the female. The cuticular bosses of the anterior end extend for a distance of 0.48–0.68 mm in the male, and of 0.93–2.6 mm in the female. They are very irregularly arranged anteriorly. More posteriorly they form about 16–24 rows, but their arrangement is very variable. The paired lateral alæ begin just behind the cervical papillæ (which are situated at about 0.1–0.15 mm from the anterior extremity), and extend for a distance of 0.2–0.6 mm. The border of the mouth has a diameter of about 0.025–0.03 mm. The pharynx is 0.03–0.04 mm long. In the male the anterior portion of the œsophagus measures about 0.3–0.5 mm. in length, the posterior portion about

2.6–3.3 mm, in the female the two portions measure respectively 0.54–0.6 mm and 4.5–6 mm. The excretory pore is situated at 0.3–0.56 mm, and the nerve-ring at 0.21–0.47 mm, from the anterior end.

The tail of the male is about 0.18–0.3 mm long. The left caudal ala is slightly longer than the right. The caudal papillae are very variable in number and usually asymmetrical. There may be up to seven preanal and five postanal papillae on each side, but there may also be as few as two or three postanal papillae on one side or the other, and Wharton (1918) records a specimen in which there were no preanal papillae at all on the right side. Wharton examined a considerable number of specimens from the Philippines, and concluded that the most usual number of papillae was ten pairs. The length of the left spicule also appears to be very variable, as in other species of the genus. Ransom (1904) states that in American specimens it is at least as long as the body of the worm (17–19 mm), and that in the retracted state it is "bent back and forth". Wharton also, for specimens from the Philippines, gives the length of the left spicule as 17–19 mm. Bhalerao (1933, c), however, gives it as 10.6–12 mm for *G. suman*, while the writer found it to vary from 6 to 10 mm in four specimens from South Africa, and obtained measurements of 10.1 and 10.5 mm in two specimens from Malaya\*. The left spicule has a barb near the tip, and measures only 7–9  $\mu$  in thickness. The right spicule is alate and stouter (15–20  $\mu$  thick), and measures, according to various observers, 0.1–0.145 mm. in length. The accessory piece, which was not described by Ransom, has, according to Bhalerao, the same form as that of *G. pulchrum*.

The tail of the female is 0.15–0.35 mm long. The vulva is situated at a distance of 1.1–4 mm from the posterior end. The vagina runs forward for a distance of about 7–17 mm. The eggs are oval and measure about 0.05–0.06  $\times$  0.03–0.038 mm. According to Ransom they have shells 4  $\mu$  thick,<sup>2</sup> to the outer surface of which a very thin membrane is more or less closely adherent."

Cram (1930) records beetles of the genera *Copris* and *Phanæus* as intermediate hosts for this species in America, and has also (1935) infected the cockroach *Blattella germanica* experimentally.

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\* Smit and Notosoediro (1926) have described a form from the fowl in Java in which the left spicule measures 10.5 mm and the right spicule 6.58 mm. Unless there is an error in the latter measurement, it seems probable, as Cram (1927) has pointed out, that this is a different species from *G. ingluvicola*. It has been named *G. cram* by Smit (1927) (synonym, *G. notosoedironis* Strand, 1929).

Subfamily ACUARINÆ Railliet, Henry  
and Sisoff, 1912

Lips simple, conical and distinct, but small Dorsal and ventral cephalic shields absent Anterior end of body provided with "cordons," "epaulettes," or other homologous structures Pharynx usually elongate, without thickenings Preanal papillæ of male usually four pairs Accessory piece absent

1 Genus ACUARIA Bremser, 1811

Synonyms —*Anthuris* Rudolphi, 1819, *Spiroptera* Rudolphi, 1819, *Dispharagus* Dujardin, 1845 (part)

Anterior end without vesicular swelling, but bearing four cuticular 'cordons' in the form of grooves or bands sunk in, or salient from, the cuticle These cordons extend directly backwards or, more often, return forwards In the latter case they may unite in pairs across the lateral lines Adult worms in the œsophagus, crop or gizzard of birds (free or burrowing in or under the lining)

Genotype —*Acuaria anthuris* (Rudolphi, 1819).

This genus was divided by Railliet, Henry and Sisoff (1912) into a number of subgenera, to which Baylis and Daubney (1926) added others Many recent authors regard these subgenera as genera, but their distinguishing characters are so slight that the present writer prefers to adhere to the former arrangement The subgenera dealt with here may be separated by means of the following key —

Cordons non-recurrent	1	
Cordons recurrent	4	
1 Cordons not anastomosed	2	
Cordons anastomosed in pairs	3	
2 Spicules of male subequal or not markedly unequal		ACUARIA, p 124
Spicules of male very unequal		CHEILOSPIRA, p 130.
3 Cordons relatively long		ECHINURIA, p 137
Cordons very short, forming crescentic epaulettes "		RUSGUNIELLA, p 139
4 Cordons not anastomosed		DISPHARYNX, p 132
Cordons anastomosed in pairs		SYNHIMANTUS, p 134

Subgenus ACUARIA (Bremser, 1811) Railliet, Henry  
and Sisoff, 1912

Cordons run straight backwards, being non-recurrent and not anastomosed Male with six to eight pairs of postanal papillæ Spicules subequal, or not markedly unequal, and relatively short and stout

Type-species —*A. (Acuaria) anthuris* (Rudolphi, 1819)

## Key to Species\*.

- Longer spicule of male 0.2 mm. or more in length, . . . . . *anthuris*, p. 127  
 Longer spicule less than 0.2 mm. long . . . . . 1  
 1. Longer spicule about 0.17 mm. long . . . . . *convexa*, p. 127  
 Longer spicule 0.6-0.9 mm. long . . . . . *heterospicula*, p. 129

1 *Acuaria (Acuaria) anthuris* (Rudolphi, 1819) Rudolphi, Henry and Nicoll 1912 (Fig. 72)

Synonyms — *Spangiera anthuris* Rudolphi, 1819 *Displacagus anthuris* Dujardin, 1845 *Elaria anthuris* Schneider, 1865 : ? *Acuaria scutata* Maplestone, 1931

Hosts — This parasite occurs in the gizzard of various Passeriform birds mainly belonging to the family Corvidæ, in Europe and Asia. It has been recorded in India from the

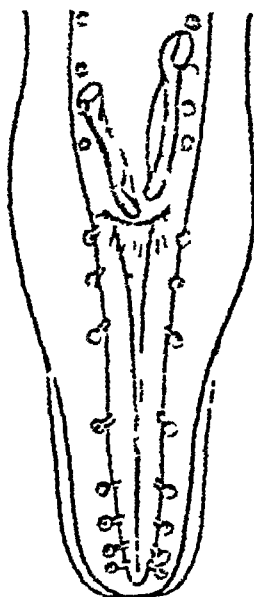


Fig. 72 — *Acuaria (4) anthuris*. Posterior end of male; ventral view (After v. Linstow)

red-billed blue magpie (*Urocissa erythrorhynchos occipitalis*) by Baylis and Drubney (1922) and from the red-billed chough (*Pyrrhocorax pyrrhocorax* [= *Graculus cremita*]), in the Zoological Gardens, Calcutta, by Maplestone (1931). Maplestone also records, under the name of *Acuaria scutata* a form from an Indian tree-pie (*Dendrocitta rufa*) in the Zoological Gardens, Calcutta, which is here regarded as probably identical with *A. anthuris*.

\* Two species, *indica* and *lata*, of which the males are unknown, are omitted from the key.

The earlier descriptions of this species were very inadequate. They have been summarized by Cram (1927). More detailed descriptions have been given by Maplestone (1931) and by Markowski (1933), the former based on Indian material from *Pyrrhocorax*, the latter on material from Polish *Corvidæ*. The two authors' measurements are in close agreement, and leave little room for doubt that they were dealing with the same species.

The male measures about 9.2–13 mm in length and 0.22–0.28 mm in maximum thickness, the female 13–31.5 mm. and 0.2–0.32 mm respectively. According to Maplestone, the thickness of the female in *A. scutata* is 0.4 mm. The cuticular striations, according to Dujardin, are prominent and at intervals of 7.4–8.3  $\mu$ . The lips are rather bluntly conical in lateral view and rounded in dorso-ventral view. The cordons extend posteriorly for a distance of about 2–3 mm in the male and of 7.5–9 mm in the female (or a little more than half the total length, according to Maplestone, in *A. scutata*)\*. The pharynx measures 0.22–0.3 mm in length, and has thick, finely striated walls. According to Maplestone, the anterior end of the pharynx forms a complicated structure as seen in lateral view, while in dorso-ventral view this structure appears globular. The total length of the oesophagus appears to vary between about 2.6 mm and nearly 5 mm, being, as usual, greater in females than in males. The anterior portion of the oesophagus, according to Dujardin, is about 1 mm long.

The caudal alæ of the male are 0.75 mm. long and relatively broad (0.3 mm in maximum width). The tail is about 0.3–0.4 mm long. Maplestone finds eleven pairs of caudal papillæ, four being preanal and seven postanal, the latter divided into groups of three and four pairs. Schneider (1866) found only six pairs of postanal papillæ. Dujardin found six to eight pairs of papillæ in all. v. Linstow (1873) found twelve pairs, of which eight were postanal, including a pair immediately behind the cloacal aperture. Markowski also states that there are twelve pairs, but his figure agrees with that of Maplestone in showing only eleven pairs. The

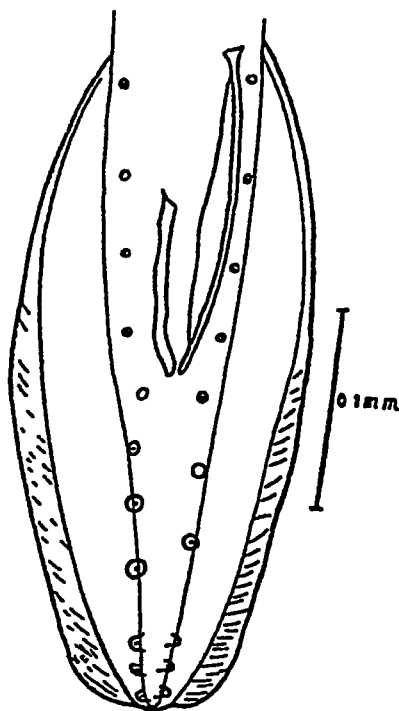
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\* Maplestone states that in *A. scutata* "a little distance anterior to the termination of these cordons two other similar structures appear, one on the mid-dorsal and the other on the mid-ventral line. They are visible for about one-fourth the total length of the worm." Maplestone further remarks that "this worm appears to be almost identical with *A. anthuris* except in one particular, viz, the extent and number of the cordons." The "accessory cordons" were not seen by him in the specimens which he regarded as *A. anthuris*. Williams (1929, b) considers that the third pair of cordons (which he terms "pseudocordons," and finds to occur in the lateral and not in the dorsal and ventral lines), "although differing considerably in degree of development, is undoubtedly present in all the species of the genus."

spicules are subequal and relatively short and broad. They measure 0.22–0.287 mm and 0.18–0.234 mm in length respectively.

The tail of the female is about 0.34–0.4 mm. long, and has a rounded tip with a pair of subterminal papillæ. The vulva is situated a little in front of the middle of the body (at 10–10.6 mm from the anterior end) according to Dujardin and Maplestone, or immediately behind the middle according to Seurat (1915, b). According to the latter author there is a funnel-shaped "ovjector" [i.e., vagina], 0.5 mm long and having a thick muscular coat. The unpaired trunk of the uterus is relatively very long (4.5 mm). The uterine branches are opposed, and are connected with the ovarian tubes by S-shaped portions which function as receptacula seminis. The eggs measure 0.039–0.048 (or in *A. scutata* 0.034–0.035)  $\times$  0.026–0.027 mm.

- 2 *Acuaria (Acuaria) conica* Maplestone, 1931 (Fig. 73)  
 Host — Magpie-robin (*Copsychus saularis*) (gizzard), Zoological Gardens, Calcutta.



73 — *Acuaria (A) conica* Posterior end of male, ventral view  
 (After Maplestone)

The male measures 6.67 mm in length and 0.092-0.1 mm. in maximum thickness, the female 12.6-16.2 mm. and 0.136-0.156 mm. respectively. The lips are conical, relatively long and pointed. The length of the cordons is 0.28-0.3 mm. in the male and 0.425-0.49 mm in the female. The pharynx, which is 0.18 mm long in the male, has thick walls with fine transverse striations. The anterior portion of the œsophagus, in the male, measures 0.3 mm in length; the posterior portion 0.69 mm.

The caudal alæ of the male are broad, and continue so to the tip of the tail, which thus appears truncate. There are four pairs of preanal and six or seven pairs of postanal papillæ, three pairs of the latter forming a group near the tip of the tail. The spicules are dissimilar and unequal, measuring 0.168 mm and 0.112 mm in length. According to Maplestone's description the right spicule is the longer, but his figure shows that it is the shorter. The left spicule is alate on its inner aspect. The right spicule is slightly stouter than the shaft of the left.

The tail of the female is 0.23 mm long. The vulva is situated behind the middle of the body, at  $\frac{2}{5}$  to  $\frac{10}{21}$  of the total length from the posterior end. The eggs measure 0.03-0.032  $\times$  0.016-0.018 mm.

### 3 *Acuaria (Acuaria) indica* Maplestone, 1932

*Host* :—Shikra (*Astur badrus*) \* (gizzard); Zoological Gardens, Calcutta

The male of this species is unknown. The female measures 22-26 mm. in length and 0.18-0.2 mm in maximum thickness. The lips are bluntly conical. The cordons are 0.44 mm. long. The pharynx is 0.2-0.21 mm. long, and has thick walls. The anterior portion of the œsophagus measures 0.55-0.61 mm. in length, the posterior portion 1.3-1.4 mm. The cervical papillæ are short and stout, and are situated at 0.25 mm. from the anterior extremity. The nerve-ring is situated at about the same level, and the excretory pore 0.1 mm. behind it.

The posterior end of the body is narrowed rather suddenly at the anus, which has rather prominent lips. The tail is 0.24-0.25 mm long, and has a blunt tip. The vulva is situated behind the middle of the body, at 9.8-12.6 mm from the posterior end, and is rather prominent. The vagina is long and muscular, and runs directly backward from the vulva.

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\* Maplestone, probably by a clerical or typographical error, calls this bird "shrike."

4 *Acuaria (Acuaria) brevispicula* Maplestone, 1932 (Fig 74.)

*Host* —Magpie-robin (*Copsychus saularis*) (gizzard); Zoological Gardens, Calcutta.

The description of this species was based on a single male specimen, which measured 4.4 mm in length and 0.126 mm in maximum thickness. The lips are conical. The cordons end a little in front of the posterior end of the oesophagus. The pharynx is 0.148 mm long, and has thick, striated walls. The anterior portion of the oesophagus measures 0.308 mm

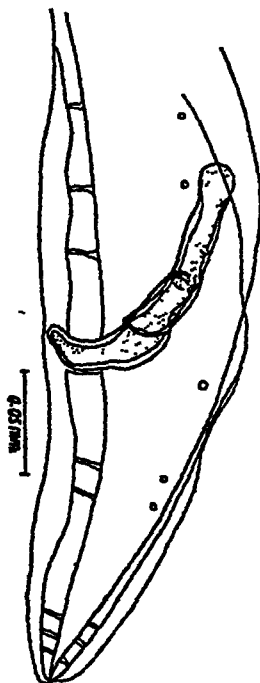


Fig 74—*Acuaria (A) brevispicula* Posterior end of male, ventro lateral view (After Maplestone)

in length, and the posterior portion 1.07 mm. The excretory pore is situated at 0.26 mm from the anterior end.

The caudal alae are relatively long and "divided into inner and outer areas". The tail is 0.172 mm long. There are nine pairs of caudal papillae, arranged in three groups of three. The anterior group is preanal, the posterior group near the tip of the tail. Between these is a postanal group near the cloacal aperture, with the anterior pair widely separated from the other two. The spicules are stout, slightly dissimilar and subequal, measuring 0.09 mm. and 0.075 mm. in length.

### 5 *Acuaria (Acuaria) lata* Maplestone, 1931.

*Host*.—Red-crested wood-quail (*Rollulus rouloul*) (gizzard); Zoological Gardens, Calcutta

The male of this species is unknown. The female measures 28.5–29 mm in length and 0.65–0.7 mm. in maximum thickness. The lips are triangular in lateral view and rounded in dorso-ventral view. There are “four coarse double cords,” which extend posteriorly for a distance of 20–21 mm. The thick-walled pharynx is about 0.26 mm long. The anterior portion of the oesophagus measures about 1.4 mm. in length, the posterior portion about 4.4 mm.

The tail is curved ventrally and is 0.6 mm. long. It has a blunt tip. The vulva is inconspicuous and is situated a little behind the middle of the body, at 15–16 mm. from the anterior end. The uterine branches are opposed. The eggs measure 0.038–0.04 × 0.024–0.026 mm.

Subgenus **CHEILOSPIRURA** (Diesing, 1861) Raillet,  
Henry and Sisoff, 1912

Cords non-recurrent and not anastomosed. Male with five to seven pairs of postanal papillæ. Spicules very unequal and dissimilar.

Type-species :—*A. (Cheilospirura) hamulosa* (Diesing, 1851).

### 6 *Acuaria (Cheilospirura) hamulosa* (Diesing, 1851) Raillet, Henry and Sisoff, 1912 (Fig. 75)

Synonyms —*Spiroptera hamulosa* Diesing, 1851; *Cheilospirura hamulosa* Diesing, 1861, *Dispharagus hamulosus* Stossich, 1890; *Filaria hamulosa* Schneidernühl, 1896; *Spiroptera perforans* Centoscuadi, 1911; *Acuaria hamulosa* Raillet, 1911

*Hosts* :—This species, which is of cosmopolitan distribution, occurs in the gizzard of the fowl and turkey, beneath the horny lining or in burrows in the muscular wall, on the surface of which it sometimes produces small nodules. Its burrows communicate with the lumen of the gizzard through openings in the lining. There are specimens in the British Museum (Natural History) obtained from a fowl in Ceylon.

The following description is derived from Tubangu (1926), Cram (1927; 1931) and Li (1934). The male measures about 8.5–15 mm in length and 0.24–0.36 mm in maximum thickness, the female about 16–25 mm. and 0.5–0.62 mm respectively. The lips are large and triangular, and each bears two large, conical papillæ, while its pulp is produced anteriorly into a finger-like process. The cords consist of double rows of irregular cuticular plaques, and are somewhat wavy anteriorly and of great length, extending through-

out at least two-thirds and sometimes almost the whole of the length of the body. The pharynx is about 0.18–0.3 mm. long. The oesophagus occupies about one-third of the total length, its anterior portion, according to Li, measuring 0.67–1.25 mm and its posterior portion 2.23–4.6 mm. The nerve-ring is situated at 0.25–0.45 mm from the anterior extremity.

The caudal end of the male is coiled and provided with relatively wide alæ having double contours. The tail is about 0.4–0.7 mm long, and its tip projects beyond the alæ. The cloacal aperture is surrounded by a prominent cuticular ring. There are ten pairs of pedunculate caudal papillæ, of which four are small and preanal. Of the postanal papillæ

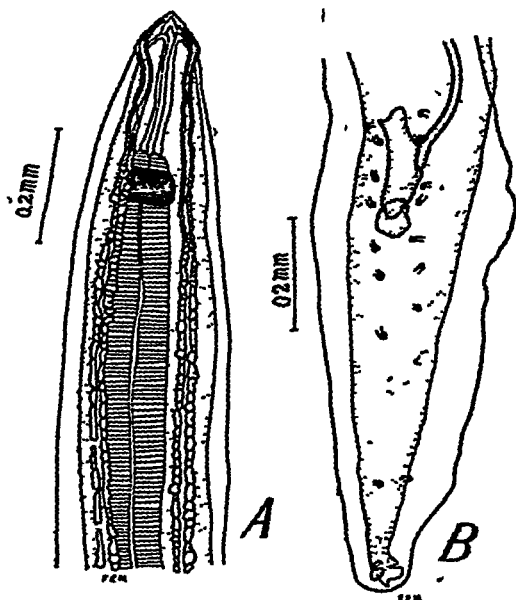


Fig 75—*Acuaria* (*Cheilospirocha*) *hamulosa*. A, anterior end, lateral view; B, posterior end of male, ventral view (From Baylis, after Tubangu) )

three pairs, increasing in size posteriorly, are situated in about the anterior third of the tail, and separated by a considerable space from the other three pairs. These lie near the tip of the tail and are often asymmetrical. The left spicule is relatively slender and measures 1.12–2.35 mm in length. The right spicule is short, broad and flattened ("shaped like a chopping knife," according to Cram), and is 0.19–0.24 mm long\*.

\* Tubangu gives 0.5 mm., but this is clearly an error, since the spicule figured is exactly 0.2 mm long according to the scale

The tail of the female is pointed and about 0.5–0.6 mm long. The vulva is situated slightly behind the middle of the body, at 10–11.3 mm from the posterior end. The eggs measure  $0.039\text{--}0.045 \times 0.02\text{--}0.027$  mm.

The intermediate hosts of this species, in America and Hawaii, according to the researches of Cram (1931), Alicata (1937) and others, include grasshoppers (species of *Melanoplus*, *Paroxya*, *Conocephalus* and other genera), various beetles and a "sand-hopper" (*Orchestia*, an Amphipod crustacean). The eggs are ingested by the intermediate host, and the larvæ which hatch from them migrate, according to Cram, into the body-cavity and develop among the tissues, chiefly in the muscles, to the third stage, which is infective for the bird host. The tissues of the intermediate host form a thin-walled cyst enclosing the larva. The third stage, according to Alicata, is reached in about 19–25 days. If the intermediate host is eaten by a suitable bird, the larvæ are freed from their cysts in the gizzard, into the wall of which they penetrate. The worms reach maturity in about 90 days.

Subgenus **DISPHARYNX** Railliet, Henry and Sisoff, 1912

Cordons recurrent but not anastomosed. Male usually with five pairs of postanal papillæ. Spicules unequal and dissimilar.

Type-species — *A. (Dispharynx) nasuta* (Rudolphi, 1819).

7 **Acuaria (Dispharynx) spiralis** (Molin, 1858) Railliet, Henry and Sisoff, 1912 (Figs 76 & 77)

Synonyms — *Dispharagus spiralis* Molin, 1858, *Dispharagus nasutus* Piana, 1897, *Dispharagus spiralis columbæ* Bridé, 1910, *Acuaria spiralis* Railliet, Henry and Sisoff, 1912, *Dispharynx spiralis* Skrjabin, 1916, ? *Spiroptera nasuta* Rudolphi, 1819\*; ? *Dispharagus nasutus* Dujardin, 1845, ? *Filaria nasuta* Schneider, 1866, ? *Acuaria (Dispharynx) nasuta* Railliet, Henry and Sisoff, 1912, ? *Cheilospirura nasuta* Ransom, 1916, ? *Dispharynx nasuta* [Stiles and Hassall, 1920] Cram, 1927

**Hosts** — This species occurs in the fowl, turkey, guinea-fowl and pigeon, and has also been recorded from a number of wild birds, chiefly Galliformes. It has a wide geographical distribution. Its principal habitat is the oesophagus and crop, where the worms are usually found with their heads buried in the mucosa. They are also occasionally found

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\* The species named *Spiroptera nasuta* by Rudolphi is very imperfectly known, and it appears not improbable that it is identical with *A. spiralis*. If this identity were definitely established, the species here described would, of course, have to take the name *nasuta*, which has priority.

in the intestine There are specimens in the British Museum (Natural History) obtained from a fowl at Pegombo, Ceylon, and from a bronze-winged jacana (*Metopidius indicus*) in the Zoological Gardens, Calcutta the latter having been determined by Dr P. A. Maplestone. The following description is based mainly on the accounts given by Seurat (1916, *b*) and Tubangui (1926), supplemented

Fig 76

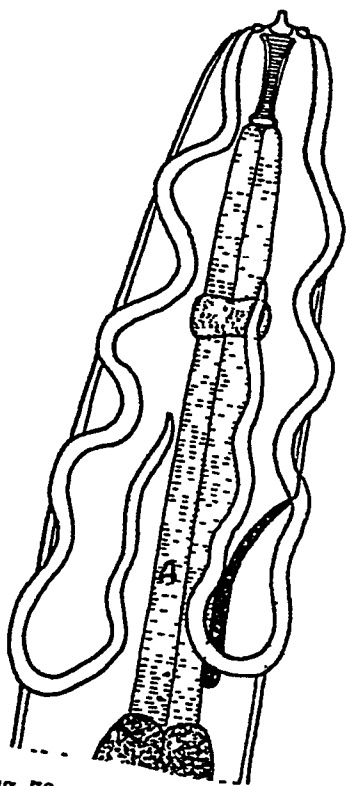


Fig 77

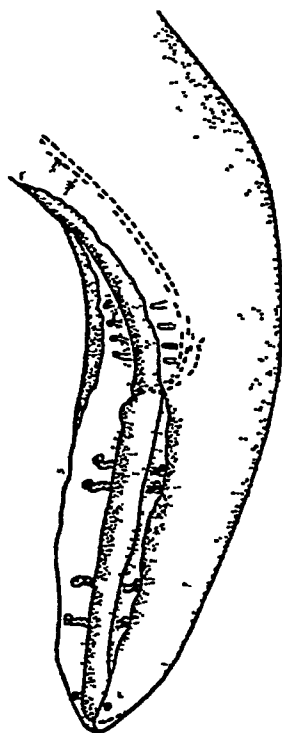


Fig 76—*Acuaria (Dispharynx) spiralis* Anterior end; lateral view.  
(After Seurat )  
Fig 77—*Acuaria (Dispharynx) spiralis* Posterior end of male; ventro  
lateral view (After Cram )

by the writer's observations on the above-mentioned material. The body is relatively stout and usually curved ventrally, especially towards the posterior end. The male measures about 4.5–8.3 mm in length and 0.27–0.5 mm in maximum thickness, the female about 5.5–10.2 mm and 0.36–0.57 mm respectively. The lips are small and conical. The cordons are wavy, and extend for a distance of about 0.42–0.52 mm.

from the anterior extremity in the male, and of 0.54–1 mm in the female. The small, bicuspid cervical papillæ and the excretory pore are situated a little in front of the posterior limit of the cordons, the former between their recurrent branches. The pharynx measures about 0.09–0.13 mm in length in the male and 0.12–0.15 mm in the female. The anterior portion of the œsophagus is about 0.5–0.9 mm long, and its posterior portion about 1.7–2.5 mm. The nerve-ring is situated at about 0.2–0.4 mm from the anterior end.

The caudal end of the male is spirally coiled. The tail is about 0.27–0.39 mm long. The cuticle of the ventral surface in the cloacal region, and for some distance in front of it, is tessellated. The caudal alæ are long and rather narrow. There are four pairs of preanal and five pairs of postanal papillæ, all pedunculate. The left spicule is slender and measures about 0.4–0.52 mm in length. The right spicule is relatively broad and boat-shaped, and is about 0.15–0.2 mm long.

The tail of the female is conical, with a button-like termination, and measures 0.11–0.15 mm. in length. Near its tip it bears a median ventral papilla, and just in front of this a pair of small subventral papillæ (caudal pores, according to Seurat). The vulva is situated in the posterior half of the body, at about 2–2.5 mm from the posterior end. The vagina forms a muscular ovejector, running at first posteriorly from the vulva, but soon bending anteriorly. The uterine branches are opposed, and the coils of the ovarian tubes lie at opposite ends of the body. The eggs measure 0.033–0.035 × 0.018–0.025 mm.

The intermediate hosts of this species are woodlice or "sowbugs" (Isopod crustaceans of the genera *Porcellio* and *Armadillidium*). This observation, first recorded by Piana in 1897\*, has been experimentally confirmed by Cram (1931), who has described the development of the larvæ. These reach the third (infective) stage in the body-cavity of woodlice within 26 days after the ingestion of the eggs. When infested woodlice are eaten by suitable birds, the worms reach maturity in a further period of 27 days.

#### Subgenus *SYNHIMANTUS* Railliet, Henry and Sisoff, 1912

Cordons recurrent and anastomosed in pairs across the lateral lines. Male usually with five pairs of postanal papillæ. Spicules unequal and dissimilar.

Type-species, —*A. (Synhimantus) laticeps* (Rudolphi, 1819)

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\* Piana called the species dealt with by him *Dispharynx nasutus*, but it was probably *A. spiralis*.

## Key to Species.

- Female little over 3 mm long . . . . . *nana*, p 137  
 Female 9 mm, or more in length . . . . . *invaginata*, p 135

8 *Acuaria* (*Synhimantus*) *invaginata* (v Linstow, 1901)  
 Railliet, Henry and Sisoff, 1912 (Fig 78)

Synonymy — *Dispharagus invaginatus* v. Linstow, 1901, *Acuaria* (*Synhimantus*) *invaginatus* Seurat, 1919, *Dispharagus egrettae* Rud., 1819 " of MacCallum, 1921, *Synhimantus invaginata* Skrjabin, 1924

*Hosts* — This species was originally described by v. Linstow (1901) from an undetermined bird from Tanganyika Territory (Langenburg, near Lake Nyasa). It was subsequently recorded by Gendre (1913) from the egret (*Bubulcus ibis* [= *B. lucidus*]) in French Guinea, and by Seurat (1919 *b*) from the same bird in Algeria and from the "héron pourpré" in Corsica. There seems to be little doubt, as Vigueras (1936) has pointed out, that the form recorded by MacCallum (1921), under the name of *Dispharagus egrettae* \*, from *Egretta candidissima* in the Zoological Park, New York, is identical with *A. invaginata*. Vigueras records the species from *Egretta alba* and *Leucophoyx thula* in Cuba. Maplestone (1931) states that it is very common in the cattle-egret (*Bubulcus ibis coromandus*) in Bengal, being found in nearly all specimens examined. The worms occur in the oesophagus, under the lining of the gizzard or, according to MacCallum, in the intestine just behind the gizzard.

v. Linstow's description has been considerably amplified by Gendre, whose specimens seem to have been much larger than those seen by the former author. MacCallum also gave a few measurements of the female. The male measures about 8.5–11.1 mm. in length and 0.22–0.29 mm. in maximum thickness, the female about 9.5–12.5 mm. and 0.31–0.44 mm. respectively. The intervals between the cuticular striations vary, according to Gendre, from about 5  $\mu$  near the anterior end to 14  $\mu$  in the middle of the body. The lips are very short. The cordons extend backward for a distance of 0.44–0.61 mm. from the anterior end. They are very broad posteriorly, attaining a maximum width of 0.12 mm. The anastomosis of the recurrent branches occurs at 0.24–0.33 mm. from the anterior end, and the tricuspid cervical papillæ are situated some distance behind the cordons, at 0.63–0.77 mm. from the same point. The pharynx measures 0.25–0.27 mm. in length in the male and 0.28–0.31 mm. in the female. The anterior portion of the oesophagus is about 0.96–1 mm. long, and its posterior portion about 3.2–3.6 mm.

\* MacCallum attributes this name to Rudolphi, but the latter author does not appear to have used it.

The caudal alæ of the male are thick and vesicular, and cover the greater part of the ventral and lateral surfaces of the caudal region, extending from a point 0.8 mm. in front of the cloacal aperture almost to the tip of the tail. The latter is short (1/119–1/95 of the total length) and blunt. There are nine pairs of caudal papillæ, four of which are preanal and five postanal. Their peduncles decrease gradually in length posteriorly. The preanal papillæ of either side form two groups of two each. Of the postanal papillæ, three on each side are lateral and form a group near the middle of the tail. One is subventral and placed immediately behind the cloacal aperture, which is situated on a large prominence. The fifth is near the tip of the tail. The spicules are very unequal and dissimilar. According to Gendre the left spicule is the

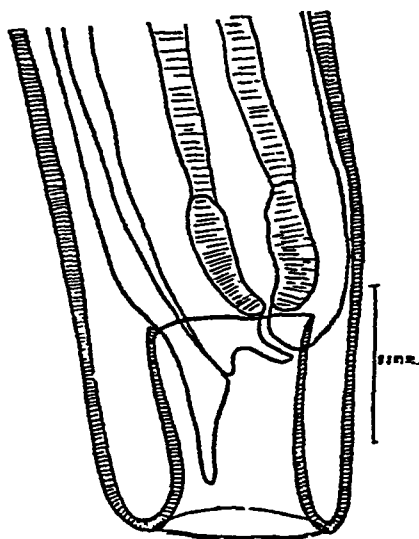


Fig 78—*Acuaria (Synhumantus) invaginata* Posterior end of female; lateral view (After Maplestone)

shorter, measuring 0.47 mm in length, and is very slender and tapering. The right spicule is 0.9 mm long, and about four times as stout as the left\*. The root of this spicule is swollen. For the greater part of its length it is cylindrical, probably owing to the alæ being rolled into a tube. Distally this tube has a somewhat bell-shaped expansion, from which the tip of the shaft projects, ending in a conical point.

The appearance of the posterior end of the gravid female is remarkable, the tail being invaginated within a prepuce-like sheath of cuticle. The anus and vulva are extremely close together, and in the invaginated condition terminal or

\* v. Lunstow gives the lengths of the spicules as 0.047 mm and 0.062 mm., the decimal points in these measurements having probably been displaced.

subterminal, the very short and bluntly conical tail being sometimes dorsally directed. According to Seurat (1914, *a*) impregnation takes place when the female is very young, and the invagination only occurs later. The same author (1919, *b*) states that the genital tube of the female is single, the coils of the ovary lying in the oesophageal region. Gendre also was able to see only a single ovary. The eggs measure  $0.024-0.029 \times 0.015-0.019$  mm.

#### 9 *Acuaria* (*Synhimantus*) *nana* Maplestone, 1931

*Host* —Golden-backed woodpecker (*Brachypternus benghalensis* [= *B. aurantius*]) (gizzard), Zoological Gardens, Calcutta.

The description of this species was based on a single female specimen. This measured 3.3 mm. in length and 0.2 mm. in maximum thickness. The lips are conical in lateral view, and are surmounted by sharply-pointed cuticular caps. The anterior portion of the body measures only 0.12 mm. in diameter, and there is a sudden increase in thickness behind the cordons. Of the latter the subventral pair turn forward at 0.26 mm. from the anterior end, the subdorsal pair at about 0.3 mm. The pharynx is 0.08 mm. long. The oesophagus is relatively very long. Its anterior portion measures 0.44 mm. in length, and its posterior portion 1.3 mm. The excretory pore is situated at about 0.28 mm. from the anterior end.

The tail is 0.1 mm. long, and is figured as being rather suddenly narrowed at about the middle. The vulva is situated at about 1 mm. from the posterior end. The vagina curves posteriorly from it. The uterine branches are opposed. The eggs measure  $0.018 \times 0.009-0.01$  mm.

#### Subgenus *ECHINURIA* Soloviev, 1912

*Synonym* —*Hamannia* Raillet, Henry and Sisoff, 1912

Cordons non-recurrent or occasionally very slightly recurrent, anastomosed in pairs across the lateral lines. Body sometimes bears longitudinal rows of spines. Male usually with four or five pairs of postanal papillae. Spicules unequal and dissimilar.

*Type-species* —*A. (Echinuria) jugadornata* Soloviev, 1912

#### 10 *Acuaria* (*Echinuria*) *hargilæ* Baylis and Daubney, 1923. (Figs 79 & 80)

*Synonyms* —*Acuaria (Echinuria) leptoptili* Baylis and Daubney, 1922, *nec* Geddoelst, 1916; *Echinuria hargilæ* Cram, 1927

*Host* —Adjutant-stork (*Leptoptilos dubius*); Calcutta

The male measures 11–11.5 mm. in length and about 0.23 mm. in maximum thickness, the female 13–15 mm. and about 0.36 mm. respectively. The cuticular striations

are at intervals of about  $4\mu$ . Cuticular spines are absent. The cordons extend back for a distance of 0.95–1.1 mm from the anterior end, and are 0.02 mm wide. Their transverse connections bend forward slightly as they cross the lateral lines. The cervical papillæ are situated a little behind these lateral bends. The pharynx is 0.3–0.31 mm long,

Fig 79

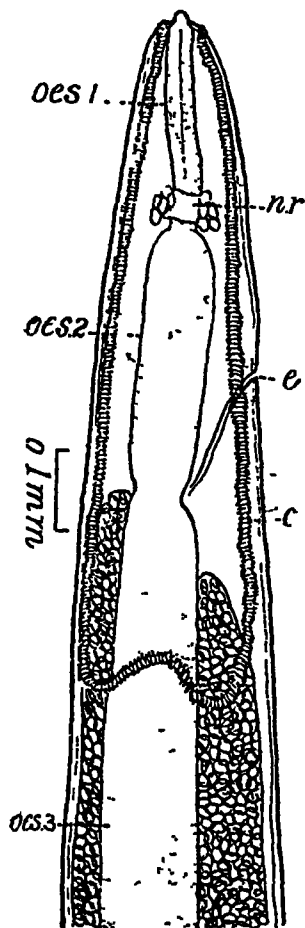


Fig 80

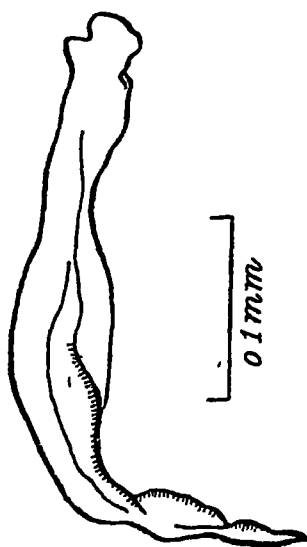


Fig 79.—*Acuaria (Echinuria) hargillæ* Anterior end of female, lateral view. *c*, cordons, *e*, excretory pore, *nr*, nerve-ring, *oes*<sup>1</sup>, *oes*<sup>2</sup>, *oes*<sup>3</sup>, three divisions of oesophagus. (After Baylis and Daubney)

Fig 80.—*Acuaria (Echinuria) hargillæ* Left spicule, lateral view. (After Baylis and Daubney)

the anterior portion of the oesophagus 0.41 mm, and its posterior portion 2.3 mm. The nerve-ring is situated at about 0.27 mm, and the excretory pore at about 0.54 mm, from the anterior end.

The caudal end of the male forms several turns of a spiral.

The alæ extend for a distance of about 0.7 mm. from the posterior extremity. The tail is about 0.115 mm long. There are nine pairs of caudal papillæ, of which four are preanal, about equidistant from each other and close to the cloacal aperture. Of the postanal papillæ four pairs form a group occupying the posterior half of the tail, and one pair is about mid-way between this group and the cloacal aperture. All the papillæ have slender peduncles, those of the preanal papillæ being much longer than those of the postanal, and increasing in length anteriorly. The right spicule is slender and measures about 0.65–0.675 mm in length. The left spicule is 0.19–0.21 mm long, and is much curved, irregularly twisted and flanged, with an expanded root. Its edges are faintly serrated in the distal portion. The coils of the testis extend to within 3.5 mm of the anterior end.

The tail of the female is 0.05 mm long. The vulva is situated at about 0.17 mm from the posterior end. Its anterior lip forms a prominent swelling. The vagina runs straight forward from it for a distance of about 1.4 mm, then bends transversely to join the uterus. The posterior branch of the uterus is represented by a blind sac which runs back to the vicinity of the vulva. The anterior branch runs forward to within 1.75 mm of the anterior end before joining the ovarian tube, which runs posteriorly. The eggs measure  $0.028 \times 0.018$  mm.

#### Subgenus *RUSGUNIELLA* Seurat, 1919 \*

Cordons very short, non-recurrent but anastomosed in pairs \* so as to form two crescentic "epaulettes". Male with five pairs of postanal papillæ. Spicules very unequal and dissimilar. Type-species — *A. (Rusguniella) elongata* (Rudolphi, 1819).

#### 11. *Acuaria (Rusguniella) brevis* (Maplestone, 1931) † (Fig. 81)

Synonym — *Rusguniella brevis* Maplestone, 1931.

Host — Kingfisher (*Ceryle alcyon*) (gizzard), Zoological Gardens, Calcutta.

\* Except for the extreme shortness of the cordons, it appears doubtful whether this subgenus can be distinguished from *Echinuria*.

† Chitwood and Wehr (1934) regard the *Rusguniella* of Maplestone as distinct from *Rusguniella* Seurat, 1919, and synonymous with *Aviculariella* Wehr, 1931. Although in the posterior position of the vulva Maplestone's species agrees more closely with *Aviculariella alcyona* Wehr than with the genotype of *Rusguniella* (*R. elongata* (Rud.)), Williams (1929, a) has shown that the vulva is not always in front of the middle of the body in *Rusguniella*. Wehr's species is certainly not identical with Maplestone's, and the differences between *Aviculariella* and *Rusguniella* are so slight that they may be of specific importance only. For these reasons Maplestone's species is allowed to remain in the subgenus *Rusguniella*.

The male measures 4.75 mm in length and 0.116 mm. in maximum thickness, the female 7.3 mm and 0.14 mm. respectively. The body is tapering anteriorly. The lips are conical and pointed. The cordons extend for a distance of 0.044 mm from the anterior end in the male, and of 0.15 mm in the female. They are concentrically striated. Immediately behind the cordons there is "a transverse groove in the cuticle which is most marked laterally on account of the narrow lateral flanges." The pharynx is 0.196 mm long, and is somewhat funnel-shaped at its anterior end in lateral view. Its wall is finely striated. The total length of the oesophagus, in the male, is 1.4 mm. The nerve-ring is situated at 0.23 mm from the anterior end in the male, and at 0.31 mm.

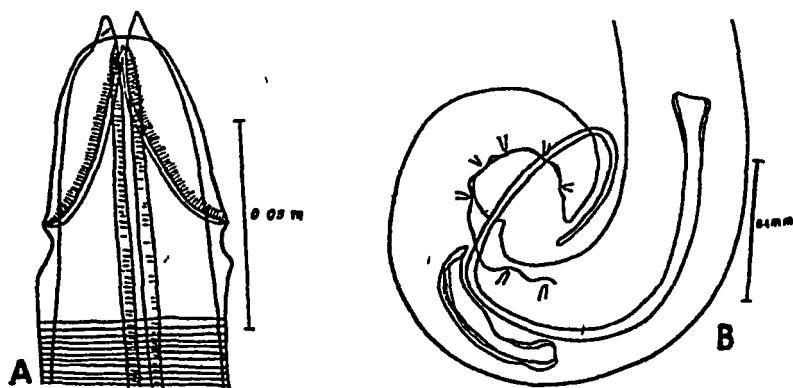


FIG. 81.—*Acuaria (Rusquimella) brevis*. A, anterior end, dorsal view; B, posterior end of male, lateral view. (After Maplestone.)

in the female. In the latter the excretory pore is at 0.36 mm from the same point. The cervical papillæ were not observed.

The caudal end of the male is curved ventrally. Caudal alæ are present. There are seven pairs of pedunculate caudal papillæ, two preanal and five postanal. The spicules are very unequal and dissimilar. The longer spicule measures 0.5 mm in length, and is slender, with a pointed tip and an expanded root. The shorter spicule is 0.14 mm long, and is stout and curved.

The tail of the female is about 0.11 mm long, and is straight, ending in "a blunt point surmounted by a cuticular cap." The prominent caudal papillæ are situated at about the middle of the tail. The vulva is situated at about 0.15 mm from the posterior end. The vagina is stout, and curves posteriorly for a short distance from the vulva to join a wide ovejector which runs posteriorly to a point more than half-way between the vulva and the anus, then becomes narrower and turns forward, giving off the two uterine branches just in front of the vulva. The eggs measure  $0.06 \times 0.036$  mm.

## SUBGENUS UNCERTAIN

12 *Acuaria macrolaima* (v Linstow, 1906) Railliet, Henry and Sisoff, 1912

Synonym — *Dispharagus macrolaimus* v Linstow, 1906

Host — Indian darter (*Anhinga* [*Plotus*] *melanogaster*) (stomach), Wirawila, Ceylon

Of this species the type-specimens are apparently not in the Colombo Museum, and the only available description is that given by v Linstow (1906, d), which is as follows:—

"Females only in the collection, 7.3–11.4 [mm] × 0.28–0.47 [mm], cuticle annulate, with elevated lateral lines; head with two small, conical, rounded lips, the mouth leads into a long vestibule; œsophagus very long, 1/2.6 [of total length], tail 1/37 [of total length], terminating in a small finger-shaped point, the nuchal pleats [i.e. cordons] run 0.80 mm backwards, rather beyond the first section of the œsophagus, immediately before their termination there is on each side a cone-shaped nuchal papilla, eggs very numerous, with a double shell, 0.031 × 0.011 [mm]"

## Subfamily TETRAMERINÆ \* Railliet, 1915

Sexes dimorphic, the body of the male being filiform, that of the mature female greatly distended, so as to become fusiform or subglobular. In the latter case the œsophageal and caudal regions remain normal. A short buccal capsule present, without thickenings. Male without caudal alæ. Caudal papillæ sessile or replaced by spines. Spicules unequal. Accessory piece absent. Vulva towards the posterior end of the body.

*Key to Genera.*

Body of mature female subglobular	Male usually with rows of spines	TETRAMERES, p 142
Body of mature female spindle shaped	and spirally coiled	[p 144]
Male without spines		MICROTETRAMERES,

\* The systematic position of the worms included here is somewhat uncertain. Travassos (1914, c) erected a family Tetrameridæ for their reception, but it is felt that there is little justification for separating them from the Spiruridæ. Baylis and Daubney (1926) placed them in an appendix to the subfamily Acuarinæ, a group with which they seem to have fairly close affinities. They also, however, show some resemblances to *Oxyspirura*, a genus usually referred to the Thelazinæ. The marked sexual dimorphism exhibited by them, and the absence of caudal alæ and pedunculate papillæ in the males, suggest that they should be treated as an independent subfamily.

1 Genus **TETRAMERES** Creplin, 1846 \*

Synonyms —*Tropisurus* Diesing, 1835, *Tropidurus* Wiegmann, 1835, *nec* Neuwied, 1824, *Tropidocerca* Diesing, 1851, *Astomum* Schlotthauber, 1860; *Acanthophorus* v Linstow, 1876; *Echinuroides* Thwaite, 1926

Male whitish and slender, typically with four longitudinal rows of cuticular spines. Mature female usually blood-red, with the middle portion of the body subglobular and divided into quarters by four longitudinal grooves in the lateral and median lines. Lips small, paired †, overlapped by dorsal and ventral cuticular shields, at least in the male. Œsophagus divided into two portions. Intestine of female wide and sac-like. Caudal papillæ of male few, small and sessile, or replaced by spines. In the female a saccular diverticulum of the vagina may be present. Adult worms in the proventriculus of birds, the males free in the lumen, the females partly buried in the gastric glands, with their posterior ends protruding.

Genotype —*Tetrameres paradoxa* (Diesing, 1835)

1. **Tetrameres spinosa** (Maplestone, 1931) (Fig 82)

Synonym —*Echinuria spinosa* Maplestone, 1931

*Hosts* .—Pochard or dun bird (*Nyroca* [*Aythya*] *ferina*) and an unidentified duck; Zoological Gardens, Calcutta

Of this species the male only was obtained. This measures 4.7 mm. in length and 0.12–0.4 mm in thickness. The body bears spines which are irregularly arranged at the anterior end, then in four longitudinal rows on each side. Behind the excretory pore these are reduced to two rows, one on each side of the lateral ala. The spines become smaller and more widely separated posteriorly. The lips are thick and bilobed, and each bears two papillæ. Dorsal and ventral cephalic shields are present. The lateral alæ arise at the bases of the lips and extend throughout almost the whole length of the body. "Cordons" are also said to be present. These arise from elongate oval prominences on each side of the

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\* There appears to be a consensus of opinion that *Tetrameres* is the correct name for this genus, and Baylis and Daubney's (1926) retention of the earlier name *Tropisurus* has not been generally accepted. The position is that, under the International Rules of Zoological Nomenclature, the emendation by Wiegmann of *Tropisurus* to *Tropidurus* was justifiable, but *Tropidurus* was a "dead" homonym, and the emendation therefore could not stand. Strict application of the rules appears to lead to the somewhat absurd conclusion that in these circumstances *Tropisurus* must disappear and be replaced by the next earliest name, *Tetrameres* (see Stiles and Baker, 1930, Journ Parasitol xvi, p 163)

† The statement sometimes made, e.g. by Travassos (1914, c) and by Cram (1927), that there are three lips is erroneous

head, from which they pursue a wavy posterior course, being roughly parallel. They fuse just anterior to the cervical papillæ, and curving ventrally to these structures they gradually become less well-defined and finally disappear in the lateral flanges. The "vestibule" is thick-walled and measures about 0.032 mm. in length and 0.02 mm. in width. The anterior portion of the oesophagus is 0.32 mm long, the posterior portion about 1 mm. The cervical papillæ are large and well defined, and are situated at 0.14 mm from

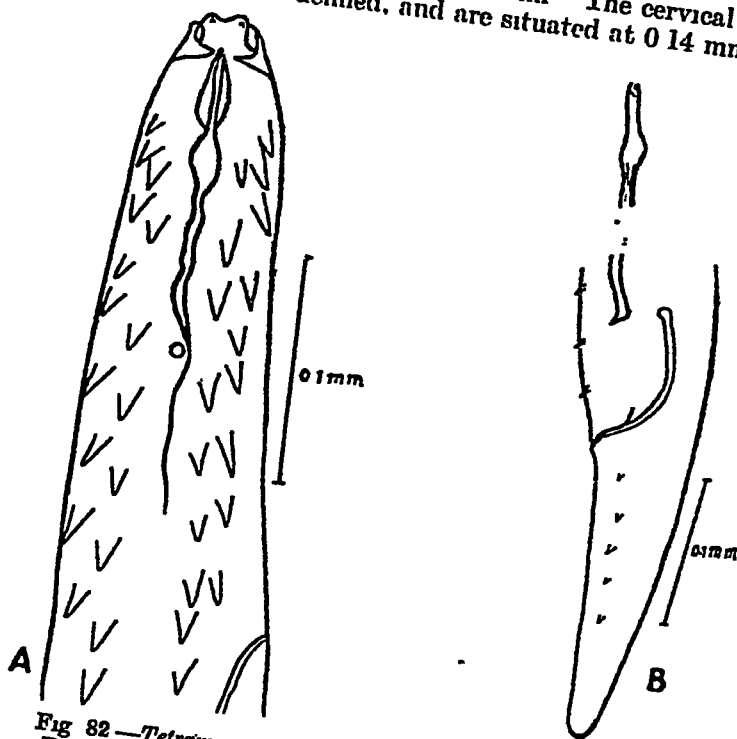


Fig 82—*Tetrameres spinosa* A, anterior end, lateral view, B, posterior end of male, lateral view (After Maplestone)

the anterior end. The excretory pore is at 0.28 mm from the same point.

The tail is straight and has a rounded tip. From Maplestone's figure it appears to be about 0.2 mm long. There are no caudal alæ or papillæ, but subventrally on each side there is a row of five spines. In front of the cloacal aperture there is a single row of spines in the mid-ventral line. The spicules measure respectively 0.4 mm and 0.044 mm in length. The longer spicule is stout. Its point is "shaped like a foot," and its root rounded and followed by a bulbous swelling. The shorter spicule is slender, curved and sharply pointed, with a rounded, knob-like root.

## 2 Genus **MICROTETRAMERES** Travassos, 1915 \*

Closely resembles *Tetrameres* in general structure. Male whitish, slender or relatively stout, without cuticular spines. Mature female usually blood-red, with the body relatively elongate, spindle-shaped and spirally coiled. Caudal papillæ of male few, small and sessile. Adult worms in the proventriculus of birds, the males free in the lumen, the females in the gastric glands.

Genotype — *Microtetrameres cruzi* (Travassos, 1914)

### 1 *Microtetrameres spiralis* (Seurat, 1915) Cram, 1927

Synonyms — *Tropidocerca spiralis* Seurat, 1915, *Tetrameres (Microtetrameres) spiralis* Travassos, 1915

*Hosts* — This species was originally recorded from the crop of *Bubulcus lucidus* in Algeria. Maplestone (1931) records it from wild examples of the cattle egret (*Bubulcus ibis coromandus*) picked up dead in the Zoological Gardens, Calcutta.

According to the original description by Seurat (1915, c) the male is white and measures 4.75 mm. in length and 0.13 mm. in maximum thickness. The female is of a light cochineal colour, and its body is coiled in a spiral of three and a half turns. It measures 2.5 mm. in length and 2 mm. in width. The buccal capsule is cylindrical in the male and shaped like an amphora in the female. In both sexes it is 0.03 mm. long. The oesophagus of the male occupies a quarter of the total length, and its anterior portion one-fifth of the whole. The anterior portion of the oesophagus in the female is 0.175 mm. long. The cervical papillæ, in the male, are situated behind the nerve-ring, at a distance of 0.3 mm. from the anterior end. The excretory pore is at 0.275 mm. from the same point.

The tail of the male is conical, with a pointed tip, and measures 0.31 mm. in length. The lips of the cloacal aperture are prominent, especially the posterior lip. There are two pairs of preanal and two pairs of postanal sessile papillæ. The left spicule is slender and measures 2.3 mm. in length (almost  $\frac{2}{3}$  of the total length). The right spicule is 0.145 mm. long.

The cuticle of the female is transversely striated, and forms a loose sheath in the posterior region, from which the tail protrudes for a distance of 0.18 mm. The tail is 0.225 mm. long, and tapers rapidly. Its tip is rounded,

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\* Proposed as a subgenus of *Tetrameres* by Travassos, but raised to generic rank by Cram (1927)

but has a small terminal spike. The vulva is situated at 0.13 mm from the anus. The combined length of the vagina and the unpaired portion of the uterus is 2.6 mm. The oviducts measure 0.3 mm in length, and the slender ovaries 6.5 mm. The eggs measure  $0.05 \times 0.03$  mm. Their shells are thick and oval, with one side flattened.

### Subfamily PHYSALOPTERINÆ Stossich, 1898

Lips simple, relatively large, with one or more forwardly-projecting teeth on their inner surfaces, and frequently followed by a cuticular collar, which is entire and does not form dorsal and ventral cephalic shields. Pharynx or buccal capsule usually absent. Accessory piece absent.

#### Key to Genera

Pharynx present	THEBUNÆ, p. 160
Pharynx absent	1
1 Caudal alæ of male joined ventrally in front of cloacal aperture. Vulva in anterior half of body.	[p. 145 PHYSALOPTERA,
Caudal alæ of male not joined in front of cloacal aperture. Vulva near anus.	PROLEPTUS, p. 162

### 1 Genus PHYSALOPTERA Rudolphi, 1819

Synonyms — *Chlamydonema* Noordhoek Hegt, 1910; *Abreviata* Travassos, 1920, *Leptosoma* Travassos, 1920, nec Whitman, 1886, *Turgida* Travassos, 1920.

Head usually more or less retractile within a collar or sheath of cuticle. Each lip armed with a variable number of teeth, typically a large, external, median tooth and three internal teeth. In addition there may be a row of small denticles on the inner surface. Pharynx or buccal capsule absent. Caudal end of male with inflated lateral alæ which are continuous across the ventral surface in front of the cloacal aperture. Several (typically four) pairs of pedunculate lateral papillæ form a group in the cloacal region. A variable number of sessile subventral papillæ also present (usually three pairs preanal and five pairs postanal). Spicules unequal, subequal or equal. Vulva in the anterior half of the body. Uterus with two, four or many branches. Adult worms in the stomach or intestine of mammals, birds, reptiles and amphibians.

Genotype — *Physaloptera clausa* Rudolphi, 1819.

## Key to Species.

- |  |                                  |
|--|----------------------------------|
| Parasite of birds of prey  | <i>alata</i> , p 151             |
| Parasites of reptiles . . . . .  | 1                                |
| Parasites of mammals . . . . .   | 2                                |
| 1 Inner surface of each lip with a median simple tooth and two bifid teeth, the four uterine branches originate by dichotomous branching.              | <i>varani</i> , p 153            |
| Inner surface of each lip with marginal rows of small denticles in addition to the larger teeth, the four uterine branches originate at the same level | <i>paradoxa</i> , p 155          |
| 2 Posterior end of body without prepuce like cuticular sheath, parasite of mouse   | <i>musculi</i> , p 158           |
| Posterior end of body with a prepuce-like cuticular sheath, parasites of Felidæ  | 3                                |
| 3 Median precloacal papilla of male smaller than the other two   | <i>masoodi</i> , p 148           |
| Median precloacal papilla of male larger than the other two  | 4.                               |
| 4 Ventral surface of caudal region in male with longitudinal rows of tubercles in its middle portion   | <i>præputialis</i> , p 146       |
| Ventral surface of caudal region in male with continuous longitudinal ridges only  | [p 149<br><i>brevispiculum</i> , |

1 *Physaloptera præputialis* v Linstow, 1889 (Fig 83)

Synonyms —*Chlamydonema felineum* Hegt, 1910, *Chlamydonema præputialis* Travassos, 1917, *Physaloptera præputialis* Travassos, 1917, *Chlamydonema præputiale* Yorke and Maplestone, 1926.

*Hosts* —This species was first recorded from the domestic cat, without mention of locality, by v Linstow (1889). It has since then been found in this host and in many wild Felidæ in several parts of the world (Asia, Africa, South America). It has been recorded from the domestic cat in India by Baylis and Daubney (1923, *b*) and by Chandler (1925, *b*), and in Ceylon by Ortlepp (1923, *a*), while there are specimens in the British Museum (Natural History) from this host from Rangoon, Burma. Other Indian hosts include the fishing cat (*Felis viverrina*), jungle cat (*F. chaus*), leopard cat (*F. bengalensis*) and leopard (*F. pardus*) (Baylis and Daubney, 1922). Korke (1928) and Chandler also record the parasite from the leopard in India, Ortlepp (1923, *a*) and Chandler from the clouded leopard (*Felis nebulosa*) in India, and Thwaite (1927) from "*Felis tigrinum*"\* at Colombo, Ceylon. The worm occurs in the stomach of its hosts, usually firmly attached to the walls by the mouth. Chandler, who found it in about two per cent of the domestic cats examined by him in Calcutta, says "it appears to be a distinctly pathogenic parasite, for every one of the seven cats we have found infected, and also

\* *Felis tigrina* is a South American species, and is not indigenous to Ceylon.

the leopard, showed an inflamed and eroded stomach wall, and distinct evidence of gastro-intestinal irritation. There seems to be little doubt but that a histolytic substance is excreted by the worm."

The male measures about 13-45 mm in length and 0.7-2 mm in maximum thickness, the female about 15-55 mm and 1-2.5 mm respectively. The cuticle has fine transverse striations (at intervals of  $16\mu$ , according to v. Linstow). At the posterior end of the body, in both sexes, the cuticle forms a large, loose, prepuce-like fold which more or less

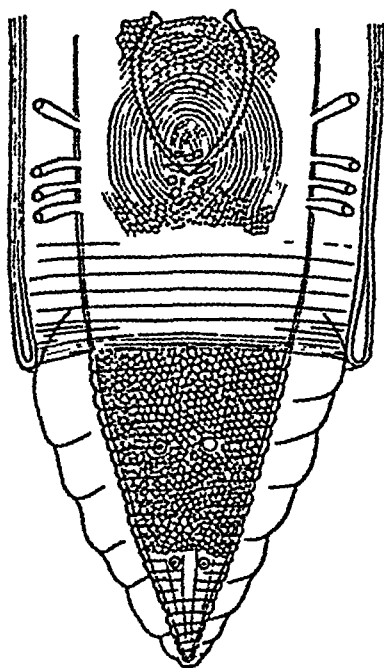


Fig 83 — *Physaloptera præputialis* Posterior end of male, ventral view (semi diagrammatic) (After Travassos)

completely envelops the tail. The lips are relatively large and conical. Each bears a blunt external tooth and three flattened and more pointed internal teeth, of the same height as the former. The oesophagus occupies about one-ninth to one-fifth of the total length, its anterior portion forming about one-eighth of the whole. The nerve-ring is situated at about the posterior third of the anterior portion, the cervical papillæ at about 0.75-0.95 mm and the excretory pore at about 0.99-1.1 mm from the anterior extremity.

The tail of the male is about 1.3 mm long according to the figure given by Ortlepp (1923, a), about 2 mm according to

Travassos (1917, a), 2.9 mm according to v Linstow, or 3.5 mm according to Korke (1928). The median ventral surface of the caudal region is ornamented with numerous rounded tubercles arranged in longitudinal rows. Towards the lateral margins of the tail, and on the alæ, these rows of tubercles are replaced by more or less continuous longitudinal ridges. The usual four pairs of pedunculate lateral papillæ are present. On the anterior lip of the cloacal aperture there are three sessile papillæ, the median papilla, according to Boulenger (1923), Otlepp and Korke, being much larger than the other two. Immediately behind the cloacal aperture there are three pairs of papillæ close together. These may form a triangle or a straight longitudinal series on each side. A little behind the middle of the tail there is an isolated pair of subventral papillæ, and between this pair and the tip of the tail another pair. Both v Linstow and Boulenger find a transverse row of three papillæ in this position, but Travassos regards the median "papilla" described by the former author as the nucleus of a large cell\*. The left spicule appears to vary in length from 1 mm to nearly 2 mm, the right spicule from 0.43 mm to 0.9 mm†.

The tail of the female is conical, with a blunt tip, and occupies, according to Otlepp, 1/66–1/53 of the total length. According to Travassos it is about 0.87 mm long. It bears a pair of papillæ (or "caudal pores") at about its posterior quarter. The vulva, which is not prominent, and is frequently concealed by a ring of dark-coloured cement from the cement-glands of the male, is situated somewhat in front of the middle of the body. There is a thick-walled vagina about 1.6 mm. long, leading to a large, somewhat pyriform egg-chamber. Near the posterior end of this chamber, and somewhat laterally, the two uterine tubes originate directly, there being no common uterine trunk. The eggs are oval and measure 0.045–0.06 × 0.03–0.042 mm.

## 2 *Physaloptera masoodi* (Mirza, 1934)

Synonym — *Chlamydonema masoodi* Mirza, 1934

*Host* — Jungle cat (*Felis chaus*) (stomach and intestine)

The male measures 18–33 mm. in length and 0.9–2.3 mm. in maximum thickness, the female 19–29 mm. and 0.9–2.2 mm. respectively. The cuticle of the posterior end of the body,

\* v Linstow appears to have seen only seven ventral postanal papillæ, but admits that owing to the opaque condition of his single male specimen all the papillæ may not have been observed. Hegt (1910) appears to have thought that there were eight pairs of subventral postanal papillæ and one median preanal papilla.

† According to Travassos, the spicules are equal and measure about 1.18 mm.

in both sexes, forms a prepucelike sheath, as in *P. praeputialis*. This may extend considerably beyond the posterior extremity. The lips are large and conical, and each bears a conical external tooth and three internal teeth. At the base of each lip two conical prominences are said to be present. The oesophagus occupies about one-fifth of the total length. The excretory pore is situated at 0.92 mm. from the anterior extremity, and the nerve ring surrounds the anterior portion of the oesophagus in its posterior quarter.

The male is described as having, in addition to the usual four pairs of lateral pedunculate papillae, ten sessile ventral or subventral papillae. Three of these are on the anterior lip of the cloacal aperture, forming a transverse row, of which the median papilla is the smallest. Immediately behind the cloacal aperture there are four papillae, also forming a transverse row, of which the two outer are larger than the two inner. Near the tip of the tail there is a transverse row of three papillae. The left spicule, in two specimens, measured respectively 1.28 mm. and 2.52 mm. in length, the right spicule 0.82 mm. and 1.31 mm., the latter being somewhat stouter than the former.

The tail of the female is pointed and slightly curved towards the ventral side. The vulva, which was covered by a ring of cement in adult females, was situated at 10.1 mm. from the anterior end in a specimen 23 mm. long, and is thus slightly in front of the middle of the body. The female genital organs are similar to those of *P. praeputialis*, there being two uterine branches. The eggs are not described.

From Mirza's (1934, b) description this species appears to be very similar to *P. praeputialis*, and may be identical with it. It is treated here as a distinct species because of the differences in the number and arrangement of the caudal papillae of the male. It is to be remarked, however, that the number of papillae is the same as that described by v. Linstow for *P. praeputialis*.

### 3 *Physaloptera brevispiculum* v. Linstow, 1906 (Fig 84)

*Synonyms*—*Physaloptera malayensis* Ortlepp, 1923; *Chlamydonema malayense* Yorke and Mapleston, 1926; *Chlamydonema juelleborni* Mirza and Singh, 1934

*Hosts*:—*P. brevispiculum* was very briefly described by v. Linstow (1906, d) from the stomach of the rusty-spotted cat (*Felis rubiginosa*) from Kandy, Ceylon. Through the courtesy of the Director of the Colombo Museum the writer has been able to examine v. Linstow's original material, and is satisfied that it belongs to the same species as the specimens described by Ortlepp (1923, a) under the name of *P. malayensis*.

Ortlepp records his species from the jungle cat (*Felis chaus*), tiger (*F. tigris*) and "tiger cat" from the Federated Malay States, and from a "bush cat" and a *hyæna* from Nigeria. Chandler (1925, b) records *P. malayensis* from the golden cat (*Felis temmincki*) in the Zoological Gardens, Calcutta. The form described under the name of *Chlamydonema fuelleborni* by Mirza and Singh (1934), which also seems in all probability to be identical with *P. brevispiculum*, is recorded from the domestic cat in India.

γ. Linstow's specimens, which are considerably smaller than those described by the more recent authors, are not in very good condition, but it has been possible to make out the caudal papillæ and spicules in several males. In these characters the specimens agree with Ortlepp's description and not

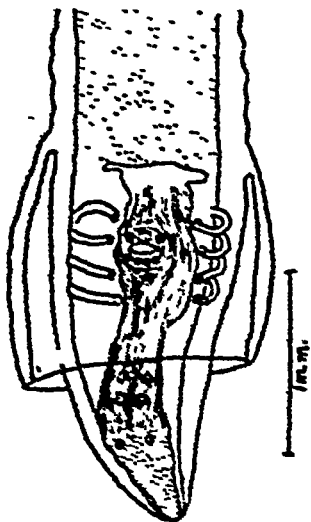


Fig. 84 — *Physaloptera brevispiculum*. Posterior end of male; ventral view. (After Ortlepp, in Proc Zool Soc.)

with γ. Linstow's. The following account is based, for the most part, on that of Ortlepp.

The male measures 11.1–30 mm. in length and 0.9–1.2 mm. in maximum thickness, the female 11.4–45 mm. and about 1.2–1 mm. respectively. There is a prepuce-like sheath of cuticle at the posterior end in both sexes, as in *P. præputialis*. "The lips are rounded, and each bears a large triangular and slightly recurved outer tooth, internal to which is the foliaceous and tripartite inner tooth of equal height" (Ortlepp). The œsophagus occupies about one-fifth of the total length in the male, and one-sixth in the female. Its anterior portion forms one-tenth to one-seventh of the whole organ, and the nerve-ring surrounds it in its posterior third. The cervical papillæ are situated about 0.13 mm. behind the junction of the two

portions of the cesophagus, and the excretory pore about 0.1 mm further back.

The tail of the male is about 1.5 mm. long. The ventral surface, from in front of the cloacal aperture to near the posterior extremity, is covered with continuous longitudinal cuticular ridges, instead of the rows of tubercles of *P. præputialis*. In addition to the usual four pairs of pedunculate lateral papillæ, v. Linstow describes only eight sessile subventral postanal papillæ. There are, however, in his specimens thirteen sessile ventral and subventral papillæ, as described by Ortlepp. Three of these, on the anterior lip of the cloacal aperture, are arranged in a transverse row, of which the median papilla is the largest. Immediately behind the cloacal aperture there are four papillæ, which form a crescentic row, as figured by Ortlepp, and not "successive couples" as described and figured by Linstow. On the posterior portion of the tail there are three pairs of papillæ, the first two close together and situated within the longitudinally ribbed area, the last a little behind the posterior limit of this area. Mirza and Singh describe and figure four pairs of papillæ on the posterior portion of the tail in *Chlamydonema fuelleborni*, but one of these may perhaps represent "caudal pores". v. Linstow describes the spicules as "very short, feebly curved, 79-81 [µm long]". In four males in his original material, however, in which the spicules could be measured, the left spicule was approximately 1.2-1.75 mm long, and the right spicule 0.55-0.66 mm. According to Ortlepp, and Mirza and Singh, the left spicule measures 1.4-2.89 mm, and the right, which is slightly stouter, 0.58-0.957 mm.

The vulva is slightly prominent, and is situated just in front of the middle of the body. It is frequently covered by a ring of dark cement. "The vulva leads into a vagina, which progressively thickens posteriorly to join a progressively thickening egg-chamber, the hind end of the egg-chamber is 330 µ in diameter, the whole organ is straight, and measures about 3.3 mm. long. From the basal end of this organ the two uteri take their origin like two horns in the same manner as in *Ph. præputialis*" (Ortlepp). The eggs, according to v. Linstow, Ortlepp and Chandler, are almost round and measure 0.033-0.036 × 0.028-0.032 mm.

#### 4 *Physaloptera alata* Rudolphi, 1819 (Fig. 85)

**Synonyms** —*Vermis dubius falconis* n. sp. Rudolphi, 1810, *Spiroptera physalura* Dujardin, 1845; ? *Physaloptera megalostoma* Creplin, 1829.

**Hosts**:—This parasite has been recorded from the stomach and intestine of a great variety of hawks and eagles, and

appears to be of world-wide distribution. Baylis and Daubney (1922) record a single immature female specimen, which was assigned to this species, from Montagu's harrier (*Circus pygargus* [= *C. cineraceus*]) in India.

Several very similar species of *Physaloptera* occur in birds of prey, and there has been a good deal of confusion between them. The identity of the form named *alata* by Rudolphi cannot, in fact, be considered very well established. Its type host, however, was the sparrow-hawk (*Accipiter nisus*), and specimens from this host described by more recent authors (Schneider, 1866, v. Linstow, 1877; Seurat, 1915, *d*; Li, 1934) may perhaps be assumed to belong to it. Ortlepp (1923, *a*), though he examined some material of Rudolphi's, did not base his description on the specimens from the type

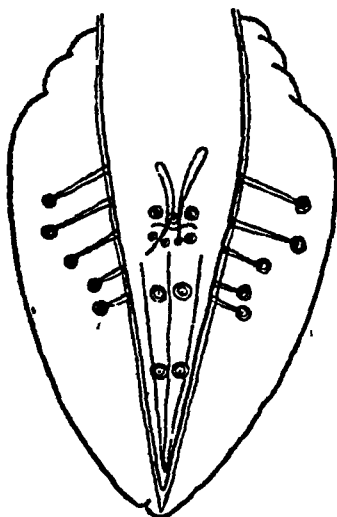


Fig 85—*Physaloptera alata*. Posterior end of male, ventral view.  
(After v Linstow.)

host, and there is some ground for thinking that he was dealing with a different species. This is unfortunate, since we are compelled to rely upon other and much less complete descriptions.

According to these, the male measures 17–23 mm in length and 0.6–0.65 mm. in maximum thickness, the female 19–34 mm. and 0.8–0.9 mm. respectively. Each lip bears a triangular external tooth and three smaller internal teeth. The oesophagus occupies about one-fifth to one-quarter of the total length. According to Li its anterior portion measures 0.51–0.59 mm. in length, and its posterior portion about 3.3–4 mm. The nerve-ring is situated somewhat behind the middle of the anterior portion (at 0.35–0.45 mm. from the

anterior end, according to Li), the cervical papillæ at about the level of the junction of the two portions, and the excretory pore somewhat further back at about 0.7-0.9 mm. from the anterior end, according to Li)

The tail of the male appears to vary in length from about 0.65 mm to 1 mm. The number and arrangement of the caudal papillæ are indicated in fig. 85. The group of lateral papillæ with long peduncles contains five pairs instead of the usual four. Of the three papillæ on the anterior lip of the cloacal aperture, the median is smaller than the others. The spicules are slender and equal or subequal. They appear to vary considerably in length, measuring, according to Seurat, 0.28 and 0.265 mm, and according to Li 0.54-0.59 mm.

The tail of the female is relatively long and tapering. According to Seurat it is  $\frac{1}{21}$  of the total length, or according to Li 0.45-0.7 mm long. The vulva varies considerably in position. According to Seurat it is situated at about the anterior fifth of the body, according to Li 2.9-5 mm and according to Schneider 7 mm from the anterior end (the last in a specimen only 19 mm long). Seurat describes the vagina as a narrow, muscular ovejector, 1.5 mm long. The common trunk of the uterus forms an egg-chamber much longer than wide, behind which there is a narrow portion, 0.3 mm long, which divides to form the two uterine branches. The ovarian tubes occupy the posterior region of the body. The eggs measure 0.045-0.055  $\times$  0.02-0.027 mm.\*

### 5. *Physaloptera varani* Parona, 1889 (Fig 86.)

Synonym :—*Abreviata* (*Abbreviata*) *varani* Schulz, 1927.

*Hosts* :—This species was described by Parona (1889, b) from the stomach of the Indian monitor (*Varanus monitor* [= *V. bengalensis*]) at Palon, Pegu, Burma. A fuller description of the worm has been given by Ortlepp (1923, a), whose material was obtained, apparently in the Zoological Gardens, London, from *Varanus bengalensis* from Ceylon and from "*V. indicus*" † from India. v Linstow (1904) records the species ‡ from *V. bengalensis* at Bolgoda, Ceylon, but gives no description. Seurat (1917) has given a description of what he considers to be *P. varani*, from various North African reptiles, but the determination of the species appears to be

\* v Linstow, probably erroneously, gives 0.125  $\times$  0.078 mm.

† The true *Varanus indicus* is not an Indian species.

‡ The writer has, through the courtesy of the Director of the Colombo Museum, seen the material referred to by v Linstow. This consists of a single female, now in so darkened a condition that it was impossible to make out the form of the uterus. The lips, however, appeared to agree with those of *P. varani*, as no small denticles could be seen on them.

open to doubt. Hsu and Hoeppli (1931) have also described, under the name of *P. varani*, specimens from a snake (*Zaocys dhumnades*) in China. Here, again, the determination seems somewhat uncertain. The following description is, therefore, derived from Parona and Ortlepp

Parona gives no measurements of the worms. According to Ortlepp the male measures 12-24 mm in length and up to 0.8 mm. in thickness, the female 17-35 mm. and 0.53-1 mm. respectively. The body tapers towards both extremities, and the cuticle has fine transverse striations. The lips are relatively large. "Each is provided with a large external tooth whose tip is slightly recurved, attached to it on its inner surface there is a small and membranous spike-like

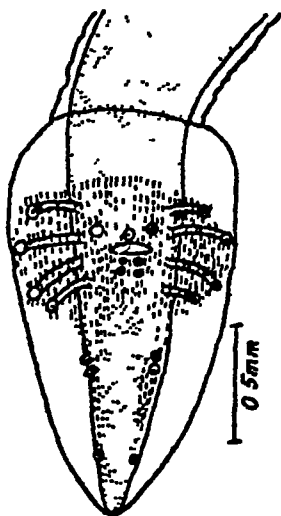


Fig 86 —*Physaloptera varani*. Posterior end of male; ventral view.  
(After Ortlepp, in Proc Zool Soc)

tooth, and on each side of it, towards the angles of the lips, there is a small bifid tooth" (Ortlepp). The oesophagus occupies about 1/6 of the total length. The nerve-ring is situated about 0.08 mm in front of, and the cervical papillae and excretory pore a short distance behind, the junction of the two portions of the oesophagus.

The caudal "bursa" of the male is nearly twice as long as broad. The tail, from Ortlepp's figure, appears to be about 1.25 mm. long. A considerable area of the ventral surface, in the cloacal region, is covered with small cuticular elevations. The caudal papillae, according to Ortlepp, are arranged as shown in fig. 86. Parona states that the median preanal papilla is oval, the two outer papillae round. He also describes and figures only four instead of five pairs of sub-

ventral postanal papillæ, having apparently missed one of the two pairs immediately behind the cloacal aperture, while he says that the three posterior pairs are equidistant, whereas Ortlepp finds that the first two are close together and widely separated from the last. According to Parona the spicules are unequal and very long. Ortlepp finds that the left spicule is filiform and 2.1 mm long, the right "broad, with almost parallel edges except for its posterior tenth," and 0.342 mm. long. Both spicules are sharply pointed.

Parona states that the tail of the female is blunt and the anus subterminal. According to Ortlepp the tail is pointed, occupies  $1/80$  of the total length, and has a pair of "caudal pores" just behind its middle. The vulva, according to Parona, is situated at 4 mm from the anterior end. According to Ortlepp it is at the anterior quarter of the body. The vagina, according to the latter author, passes gradually into an egg-chamber, and this is followed by the common uterine trunk, which returns anteriorly and divides dichotomously to form four uterine branches. The eggs, according to Parona, measure  $0.042 \times 0.023$  mm; according to Ortlepp,  $0.053 \times 0.032$  mm.

As Ortlepp observes, Parona's description might apply to many species of *Physaloptera*. *P. varani* is probably a somewhat variable form, but it must be admitted that there are a good many discrepancies between the two authors' accounts of it, and it seems possible that they may not refer to the same species.

#### 6 *Physaloptera paradoxa* v. Linstow, 1908 (Fig. 87)

Synonyms\* —*Leptosoma varani* Mönnig, 1924; *Abrexiata* (*Abbrexiata*) *paradoxa* Schulz, 1927, ? *Physaloptera achari* Mirza, 1935.

*Hosts*.—This species was originally described by v. Linstow (1908, a) from the stomach of *Varanus albigularis* and from the intestine of *Varanus* sp. in South Africa. Ortlepp (1923, a) and Mönnig (1924) have also described material from *V. albigularis*, the latter assigning it to *P. varani*. Parona Seurat (1914, b) has described, under the name of *P. paradoxa*, Algerian material from *Varanus griseus*, *Cerastes cornutus* and a chameleon. Later, however (1917), he assigns the same material to *P. varani*. Parona, and regards *P. paradoxa* as a synonym of that species. Ortlepp does not accept

\* Ortlepp considers that the species described by Geddoelst (1916) as *P. affinis* from *Psammophis sibilans* in the Belgian Congo is identical with *P. paradoxa*. Through the kindness of Dr. H. Schouteden, of the Belgian Congo Museum, Tervueren, the writer has been able to examine the types of Geddoelst's species, and finds that it is quite distinct from the form described by Ortlepp as *P. paradoxa*.

this synonymy, but it is difficult to determine with which species Seurat was actually dealing. Since he describes the uterus as having four branches which originate at the same level, it seems more probable that it was *P. paradoxa* than *P. varani*.

There appear to be no Indian records\* of *P. paradoxa*, as such, but Mirza (1934, a) records an unnamed species from "*Varanus indicus*" He states that he is unable to decide whether it is *P. varani* or *P. paradoxa*, and from his description it appears to show some of the characters of both species. The uterus is described as branching dichotomously, as in *P. varani*. On the other hand, the lips are armed with rows of denticles in the manner described by Ortlepp for *P. paradoxa* and not for *P. varani*. Moreover, Mirza has collected what

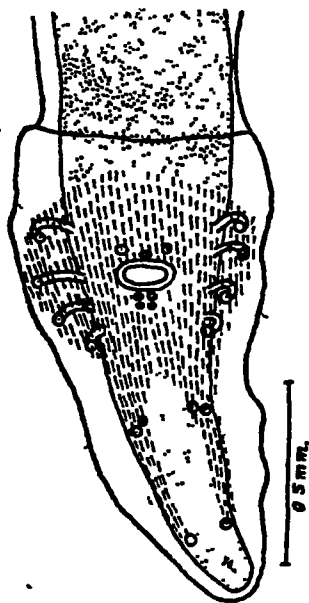


Fig 87—*Physaloptera paradoxa*. Posterior end of male; ventral view. (After Ortlepp, in Proc. Zool. Soc.)

he regards as the same species from a palm-squirrel (*Funambulus* [*Sciurus*] *palmarum*), and his description is apparently based on the material from both hosts. It is extremely doubtful whether the same species would be found as an adult in a monitor and in a squirrel†, and it appears likely, therefore, that two species are here inextricably confused.

\* Since this was written, specimens from *Varanus monitor* in Hyderabad, received from Prof B K Das, have been determined as *P. paradoxa*.

† It is also doubtful whether (as Mirza suggests) larval forms encapsuled in the tissues of the squirrel could belong to the same species as the adults in the stomach.

Mirza (1935) further describes *Physaloptera achari* from the stomach and intestine of *Calotes versicolor* in Hyderabad, and here again, the description appears insufficient to distinguish the species from *P. paradoxa*. The following description is based on the above-mentioned accounts by v. Linstow, Ortlepp and Mönnig.

The male measures 14–23 mm in length and 0.45–0.8 mm. in maximum thickness, the female 18–37 mm and 0.75–1 mm. respectively. The cuticle has fine transverse striations. The lips are relatively large. Each bears a large, wedge-shaped external tooth, slightly curved outwards and having a small, simple \* internal tooth springing from its base. Near the dorsal and ventral angles of the lip there are two bifid teeth, and between these and the median tooth, and also dorsally and ventrally to the bifid teeth, there are rows of small marginal denticles on the inner surface of the lip. The oesophagus is relatively short, occupying about 1/8 to 1/7 of the total length. The nerve-ring is near the hinder end of its anterior portion. The cervical papillæ and excretory pore are situated behind the junction of the two portions of the oesophagus, at 0.54–0.75 mm from the anteriorextremity.

The caudal alæ of the male are well developed and wide anteriorly. The ventral surface, over a considerable area surrounding the cloacal aperture, is covered with cuticular elevations. These extend posteriorly for some distance at the sides of the tail, but cease comparatively far forward in the mid-ventral region. The lips of the cloacal aperture are prominent. The tail is about 0.65–0.85 mm long. In addition to the usual four pairs of lateral pedunculate papillæ, there are at least 13 ventral and subventral sessile papillæ. Three of these are in front of the cloacal aperture, the two outer papillæ slightly in front of the median papilla. Ortlepp describes five pairs of postanal sessile papillæ, v. Linstow six and Monnig seven pairs. v. Linstow figures three instead of two pairs just behind the cloacal aperture, forming a triangle on each side, while Monnig appears to have seen two extra pairs on the more posterior region of the tail. Two pairs, at about the middle of the tail, are close together (fig. 87). The left spicule is slender and measures about 1.76–2.8 mm in length, or, according to Monnig, 3.2 mm. The right spicule is stout, with a conical point, and about 0.15–0.27 mm long.

The tail of the female appears to vary between about 0.26 mm, and 0.5 mm in length, and bears a pair of papillæ (or "caudal pores") just behind its middle. The vulva, which is not prominent, is somewhat variable in position. It may be as far back as the anterior third of the body, or as

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\* According to Mönnig (1924) this tooth is trifid.

far forward as the anterior quarter. The vagina is about 2 mm. long, and passes into an egg-chamber about 1-1.5 mm. long, followed by a short and narrow common uterine trunk. From the posterior end of this four uterine branches originate at the same level, but their cavities, according to Ortlepp, "arise by a double subdivision of the unpaired duct."\* The eggs, according to v. Linstow, measure  $0.039 \times 0.031$  mm., but according to the other authors  $0.05-0.052 \times 0.03-0.035$  mm.

7. *Physaloptera musculi* Thwaite, 1927. (Fig. 88)

*Host* :—" Domestic mouse " (intestine) ; Colombo, Ceylon.

The male measures 23.8-28 mm. in length and 0.9-1 mm. in maximum thickness, the female 38-50 mm. and 1.5-1.7 mm. respectively. The body is more tapering in front

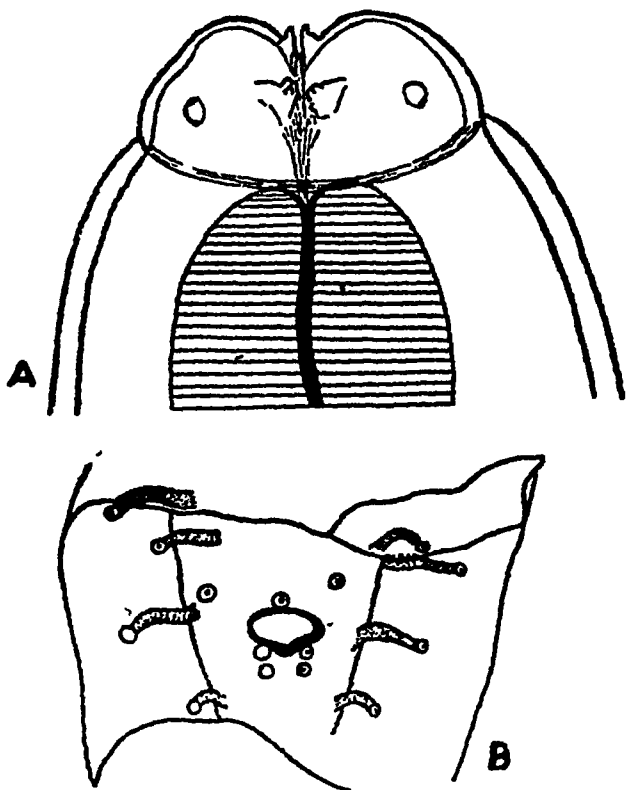


Fig 88—*Physaloptera musculi* A, anterior end, dorsal view ;  
B, cloacal region of male, ventral view (After Thwaite)

than behind. "The cuticle, which is marked by very fine transverse striations, is somewhat inflated round the anterior end of the worm . . . The inner face of each lip is armed

\* In a young specimen seen by the writer the branches originated dichotomously.

with a relatively large, median, external triangular tooth, which does not project beyond the anterior border of the lip; a smaller median internal tooth is present. Each lip, in addition, is armed on its internal face, and on each side, with three small teeth; these are irregular in size and shape, and occasionally only two appear to be present." The total length of the oesophagus is 4.4-6.4 mm. Its anterior portion measures 0.4-0.53 mm.

The tail of the male is about 1.8-2.2 mm. long. "Its ventral surface is ornamented with small cuticular elevations arranged in longitudinal rows, giving it a scaly appearance." The alæ are similarly ornamented. The papillæ in the cloacal region are arranged as shown in fig. 88, B. In addition to these there are three pairs of papillæ, equally spaced, on the more posterior portion of the tail. The left spicule is slender and measures 1.42-1.83 mm in length. The right spicule is much stouter, tapers sharply to a point, and measures 0.344-0.368 mm.

The tail of the female is short (about 0.6 mm) and conical. The cuticle of the posterior end is somewhat inflated. The vulva is inconspicuous, and is situated near the posterior end of the oesophagus, at a distance of 5.5-7 mm from the anterior extremity. The uterus is described as having at least five branches, the common trunk giving off at first two, which almost immediately subdivide, one into two and the other into three branches. The eggs measure, on an average,  $0.051 \times 0.032$  mm.

### 8. *Physaloptera* spp.

The following larval or undeterminable forms of *Physaloptera* are recorded from India, Ceylon or Burma.

Parona (1889, b) records larval forms from an unnamed snake in Burma (Carin Mountains). These were 25-53 mm. long, and had mucronate tails. One of them was enclosed in a connective-tissue capsule measuring  $15 \times 5$  mm. No other characters of diagnostic value are mentioned.

v. Linstow (1904) records two specimens of an undetermined species of *Physaloptera* from the intestine of *Calotes versicolor* at Colombo, Ceylon. He gives only the following details concerning them — "Length 12.6 to 13.6 mm; diameter 0.59 to 1.12 mm, lips with three conical projections, of which the central is the highest and carries a tooth at its apex; the oesophagus is equal to  $1/5-7$  of the body length, the tail, rounded behind,  $1/16$ th of the entire length."

Stewart (1914, a) records a larval form encysted in the wall of the urinary bladder of *Bufo stomaticus* [= *B. andersoni*] at Lucknow. One of the two specimens measured 1.739 mm. in length and 0.1184 mm in maximum thickness. Each

lip carried a truncate ("nipple-shaped") apical tooth. A full description of the morphology of these larvæ is given by Stewart.

Baylis and Daubney (1922) record a single female specimen of an undetermined species of *Physaloptera* from the stomach of the Indian fox (*Vulpes bengalensis*).

The same authors record immature specimens of *Physaloptera*, about 5-7 mm in length, from the intestine of a "raket bausi" (*Coluber* sp.).

Rahimullah and Das (1933) record an undetermined species of *Physaloptera* from *Vipera russelli* in the Deccan.

Karve (1938) records immature specimens of *Physaloptera* encysted in the muscles of the dorsal body-wall of *Hemidactylus flaviviridis* at Poona.

## 2. Genus **THUBUNÆA** Seurat, 1914

Head not retractile within a cuticular collar. Lips symmetrical or asymmetrical. In the former case each lip is armed with three teeth, in the latter case the smaller lip only may be armed. A short pharynx present. A considerable area of the ventral surface of the caudal end of the male is covered with small papilliform cuticular elevations. Among these are the terminations of the true papillæ, which vary considerably in number and are often asymmetrical. At least three pairs are preanal. Spicules short, subequal, usually feebly chitinized. Vulva towards the anterior end of the body. Vagina and two parallel uterine branches run posteriorly. Adult worms in the stomach or intestine of lizards and snakes.

Genotype:—*Thubunæa pudica* Seurat, 1914

### 1. *Thubunæa dactyluris* Karve, 1938. (Fig 89)

Synonym:—*Thubunæa asymmetrica* Patwardhan, 1935, nec Baylis 1930

Hosts:—*Hemidactylus flaviviridis* (stomach and intestine) Nagpur, Central Provinces (Patwardhan) and Poona (Karve). *Calotes versicolor* (stomach), Poona (Karve).

Patwardhan (1935, b) briefly described specimens of *Thubunæa* which he assigned to *T. asymmetrica* Baylis, 1930 a species originally described from *Mabuya maculilabris* in Africa (Uganda). Karve (1938) has given a fuller description of what he regards as Patwardhan's species, which he considers distinct from *T. asymmetrica* and names *T. dactyluris*. The characters differentiating this form from *T. asymmetrica* are very slight, and it seems possible that it may be no more than a race or variety of the latter.

The male measures 6·87 mm in length and about 0·19 mm. in maximum thickness, the female 11·5–19·4 mm. and 0·23–0·31 mm. respectively. The lips are unequal, the left being

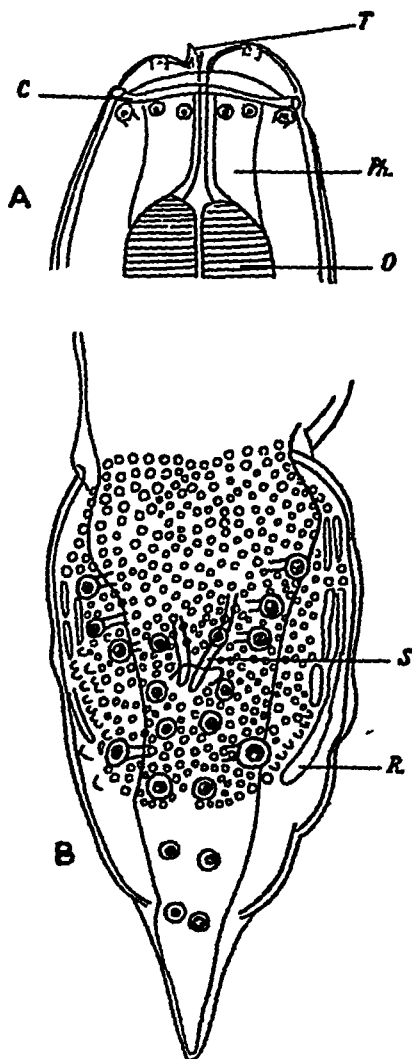


Fig. 80.—*Thubunæa dactylurus*. A, anterior end of female, dorsal view. C, cuticular collar, O., oesophagus; Ph, pharynx, T., middle tooth B, posterior end of male, ventral view. R, cuticular ridge (confluent tubercles); S, left spicule (After Karve)

smaller than the right, and each bears three papillæ. The left lip is armed on its inner surface with three forwardly-directed

teeth, the middle tooth being stout and somewhat curved outwards, the other two teeth shorter and more slender. Behind the bases of the lips there is a slight cuticular collar, and just behind this a ring of papillæ, six of which are visible in dorsal or ventral view, and four in lateral view. The distance from the anterior extremity to the end of the pharynx is about 0.024–0.034 mm according to Karve, or 0.05 mm according to Patwardhan, to the end of the anterior portion of the oesophagus about 0.26–0.35 mm., and to the end of the entire oesophagus 2.06–3.55 mm. The nerve-ring is situated at about 0.2–0.23 mm, the prominent cervical papillæ at about 0.2–0.24 mm, and the excretory pore at about 0.26–0.3 mm, from the anterior extremity.

The male has ten pairs of caudal papillæ, of which four pairs are preanal and six postanal. The tuberculated area of the ventral surface stops short of the two most posterior pairs. The left spicule measures 0.07–0.105 mm in length, the right 0.045–0.075 mm.

The tail of the female is conical and measures about 0.2 mm. in length. It bears a pair of papillæ at about 0.06–0.08 mm. from the tip. The vulva is situated at 3–3.9 mm from the anterior end, according to Karve, or at 1.21 mm. according to Patwardhan. The muscular vagina expands, at a distance of about 0.19 mm behind the vulva, into an egg-reservoir which measures about 0.38 mm in length and gives off the two uterine branches at its posterior end. The eggs have thick shells and contain embryos when ready for laying. They measure about  $0.03\text{--}0.032 \times 0.018\text{--}0.022$  mm according to Karve, or  $0.037 \times 0.025$  mm according to Patwardhan.

### 3. Genus **PROLEPTUS** Dujardin, 1845

Synonyms.—*Spiropterna* v. Beneden, 1858; *Coronilla* v Beneden, 1871, *Histocephalus* Moln, 1860 (part)

Anterior end closely resembling that of *Physaloptera*, the head usually retractile within a cuticular collar. Each lip armed with a median conical tooth, and sometimes with other smaller teeth and denticles, on its inner surface. Pharynx or buccal capsule absent. Caudal end of male spirally coiled and provided with wide alæ, not continuous anteriorly, into which project eight to ten pairs of pedunculate papillæ. Spicules unequal. Vulva near the anus. Uterine branches two, parallel. Adult worms in the stomach or intestine of fishes (chiefly Elasmobranchs). Larvæ encapsuled in Decapod Crustacea.

Genotype.—*Proleptus acutus* Dujardin, 1845

1. *Proleptus obtusus* Dujardin, 1845 (Figs 90 & 91)

Synonyms —*Coronilla scillicola* v. Beneden, 1871; *Spiropteryx scillicola* v. Linstow, 1901, *Proleptus scillicola* Lloyd, 1920; ?*Spiropteryx coronata* v. Beneden, 1878, ?*Proleptus coronatus* Yorke and Maplestone, 1926

*Hosts*.—This species is very common in the stomach, and intestine of European dogfish (*Scyllium catulus*, *S. canicula*) and has been recorded from unnamed "sharks" off the coast

Fig 91.

Fig 90

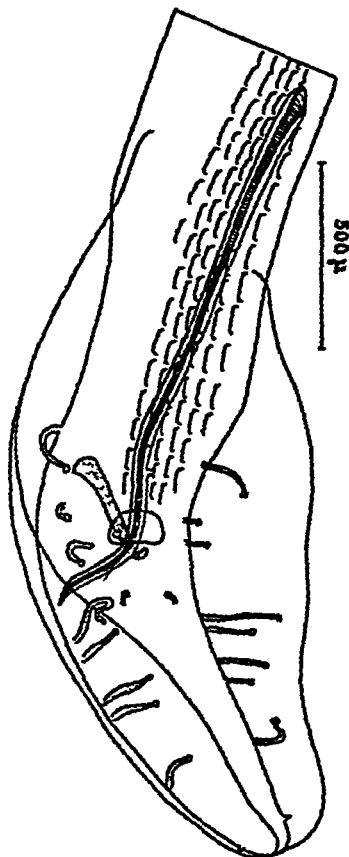
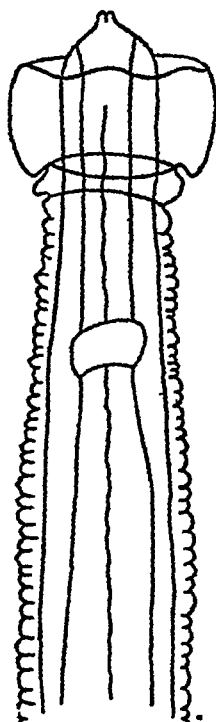


Fig 90—*Proleptus obtusus*. Anterior end (After Lloyd, in Proc Zool Soc.)

Fig 91—*Proleptus obtusus*. Posterior end of male, ventral view. (After Seurat)

of South Africa. Shipley and Hornell (1906) record it from *Aetobatis narinari*, and Taylor (1925, b) from *Acanthias vulgaris*, off Ceylon. The imperfectly-described species

*Spiropterina coronata* v. Beneden, which may be identical with *P. obtusus*, is recorded from *Scyllium canicula* and from *Raja radians*. The worms are commonly found with their anterior ends \* firmly attached to, or partly buried in, the mucous membrane of the host

The following description is derived from those given by v. Linstow (1901, a), Seurat (1919, a), Lloyd (1920) and Muller (1925). The male measures about 32-38 mm in length and 0.55 mm. in maximum thickness, the female about 32-69 mm. and 0.73-0.91 mm respectively. The body is somewhat tapering anteriorly. The lips are somewhat rounded, and each carries a single conical tooth. In young individuals there is an annular cuticular thickening just behind the lips. In the adult the outer cuticle of this thickening becomes separated from the underlying layer and forms a prominent circular fold or collar which may be turned back like an umbrella, or forward so as to surround the lips like a cup. The œsophagus measures about 3.6-4.9 mm in length in the male, and 3.7-6.9 mm. in the female. The nerve-ring is situated at 0.4-0.65 mm, the cervical papillæ at 0.46-0.54 mm, and the excretory pore at 0.67-1.17 mm from the anterior extremity.

The tail of the male is about 1-1.76 mm. long. There are wide caudal alæ, about 2 mm long, into which project eight pairs of lateral pedunculate papillæ. Three of these are preanal or adanal and five postanal. The anterior and posterior of these papillæ on each side are isolated, while the remainder form three pairs, one adanal and two postanal. Seurat figures, in addition, a pair of subventral papillæ with shorter peduncles, a little behind the cloacal aperture, and a pair of small lateral papillæ (or "caudal pores") close to the tip of the tail. The ventral surface of the body, for some distance in front of the cloacal aperture, is covered with elongate, quadrangular, cuticular elevations arranged in longitudinal rows. The left spicule measures about 1.32-2.13 mm. in length, and is slender, transversely striated and pointed. At about its distal third it carries a small tubercle on its dorsal surface. Proximally this spicule consists of a tubular shaft. Distally to the tubercle the shaft becomes much narrower, and bears a pair of inflated alæ which are folded inwards over its ventral surface, for the greater part of their length, so as to form a tube. The right spicule is 0.36-0.41 mm long. It usually lies almost at right angles to the longitudinal axis of the body, and is of a very

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\* Lloyd makes the curious statement that the worms, when attached, are always attached by the tail-end.

characteristic shape Its proximal half is stout and of nearly uniform thickness (about  $40\mu$ ), but distally it is tapering. Its tip is bent towards the left side, almost at right angles to the main shaft, and appears to form a guide for the left spicule

The tail of the female is about 0.4–0.7 mm. long, and is constricted behind the anus to form a digitiform process, which is bent towards the dorsal side It has a small terminal spike and bears, according to Seurat, a pair of "caudal pores" at 0.042 mm from its tip The vulva is situated at about 0.89–1 mm from the posterior extremity. The cuticle surrounding it is often much inflated The vagina is short, and consists of a pyriform, muscular ovejector, about 0.35 mm long, and a narrower cylindrical portion of about the same length The unpaired trunk of the uterus is also very short The uterine branches run forward parallel to each other as far as the anterior region of the intestine, and then turn posteriorly. At their posterior ends they pass into short, narrow oviducts which turn forward to join the anteriorly-directed ovaries The eggs have very thick shells measuring about  $0.047\text{--}0.052 \times 0.029\text{--}0.037$  mm.

Larval forms, possibly belonging to this species, have been recorded from various crabs (*Carcinus mænas*, *Portunus marmoratus* [= *P. depurator*], *Pagurus bernhardus*, *Hyas araneus*) Seurat (1919, a) suspects that an Amphipod of the Gammarid family also serves as an intermediate host

### Subfamily THELAZIINÆ Baylis and Daubney, 1926.

Lips inconspicuous or absent Dorsal and ventral cephalic shields absent A buccal capsule usually present, without spiral or annular thickenings Preanal papillæ of male typically numerous Accessory piece usually absent

#### Key to Genera

- |   |                       |
|---|-----------------------|
| Cuticular annulations with prominent edges  |                       |
| Buccal capsule relatively short   | 1                     |
| Cuticular annulations not prominent   |                       |
| Buccal capsule elongate and tubular, with an expansion anteriorly                                       | 3                     |
| 1 Edges of annulations without spines   | THELAZIA, p. 166      |
| Spines present on edges of annulations  | 2                     |
| 2 Uterine branches opposed  | SPINITECTUS, p. 171   |
| Uterine branches parallel   | THYLACONEMA, p. 174   |
| 3 Buccal capsule with longitudinal ribs in wall of expanded anterior portion, and with teeth anteriorly | RHABDOCHONA, p. 176   |
| Buccal capsule without ribs or teeth  | QUASITHELAZIA, p. 177 |

1 Genus **THELAZIA** Bosc, 1819

Synonym :—*Thelazius* Bosc, 1819.

Cuticle with relatively coarse transverse striations or annulations, the posterior edges of which are usually prominent, giving the body a serrated appearance in profile. A buccal capsule present, of variable shape, but usually more or less cup-shaped, and having its anterior edge cut into six festoons. Tail of male short and blunt, without alæ. Preanal papillæ numerous, frequently including an unpaired precloacal papilla. Two to four pairs of postanal papillæ present. Spicules unequal. Accessory piece absent. Tail of female bluntly rounded. Vulva in anterior region of body. Uterine branches parallel, running posteriorly. Female viviparous. Adult worms in the lachrymal ducts or beneath the eyelids of mammals (occasionally in the aqueous humour of the eyes), or under the nictitating membranes of birds.

Genotype —*Thelazia rhodesii* (Desmarets, 1828)

### Key to Species

- |  |                            |
|--|----------------------------|
| Outside diameter of buccal capsule greatest at its base . . . . .                              | 1.                         |
| Outside diameter of buccal capsule greatest at its middle or anteriorly . . . . .              | 2                          |
| 1. Longer spicule of male 0.3 mm. or more in length; parasite of camels . . . . .              | <i>leesei</i> , p 170      |
| Longer spicule of male 0.2 mm or less in length; parasite of Equidæ [and cattle (?)] . . . . . | <i>lacrymalis</i> , p 167. |
| 2. Longer spicule of male about 2 mm in length; parasite of dog and man . . . . .              | <i>callipæda</i> , p 169.  |
| Longer spicule of male less than 1 mm in length, parasite of cattle and Equidæ . . . . .       | <i>rhodesii</i> , p 166    |

### 1. *Thelazia rhodesii* (Desmarets, 1828) de Blainville, 1828 (Fig 92)

Synonyms —*Thelazius rhodesii* Desmarets, 1828; *Thelazia rhodesii* Gurit, 1831 (part), *Filaria lacrymalis* Gurit, 1831 (part); *Filaria bovis* Baillet, 1858, *Filaria palpebrarum* Baillet, 1858, *Thelazia rhodesii* Railliet and Henry, 1910, *Thelazia floresiana* Smit and Noto-Soediro, 1930.

**Hosts** —This is a common parasite of the eyes of cattle and buffaloes in many parts of the world. It has also been recorded from the horse in the Island of Flores (Netherlands East Indies). In India it has been recorded from cattle or buffaloes in Bombay, Madras, Central Provinces, United Provinces and Bengal, and there are specimens from Ceylon in the British Museum (Natural History).

The male measures 7.3–14 mm in length and 0.4–0.46 mm. in maximum thickness, the female 12–21 mm and about 0.47–0.5 mm respectively. The annulations of the cuticle

are prominent, and are at intervals of  $12\text{--}22\mu$ . The buccal capsule is short and wide, being widest near its anterior end. It measures  $16\text{--}22\mu$  in length and  $20\text{--}30\mu$  in width. The oesophagus is about  $0.47\text{--}0.65$  mm long. The nerve-ring is situated at about  $0.49\text{--}0.54$  mm, and the prominent cervical papillæ at about  $0.63\text{--}0.77$  mm, from the anterior extremity.

The tail of the male is blunt and measures  $0.078\text{--}0.092$  mm in length. There are 12–14 pairs of preanal and two or three pairs of postanal papillæ. The left spicule is about  $0.62\text{--}0.93$  mm long, and is filiform, with a thickening at about its anterior third. The right spicule is relatively stout and measures about  $0.1\text{--}0.15$  mm in length.

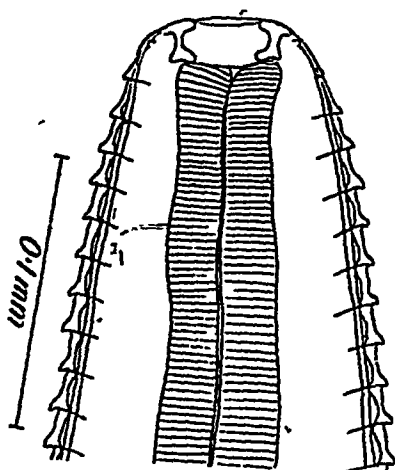


Fig 92 —*Thelazia rhodesi*. Anterior end of female, lateral view (After Baylis)

The tail of the female is about  $0.08\text{--}0.083$  mm long, and is bluntly conical, with a small terminal spike. The vulva is situated at about  $0.9\text{--}1.2$  mm from the anterior end. The embryos *in utero* measure about  $0.2$  mm in length and  $3.7\mu$  in thickness.

## 2 *Thelazia lacrymalis* (Gurlt, 1831) Railliet and Henry, 1910 (Fig 93)

Synonyms —*Filaria lacrymalis* Gurlt, 1831 (part), *Thelazia rhodesi* Gurlt, 1831 (part), *Filaria palpebralis* Wilson, 1844, *nec* Pace, 1866, *nec* Houghton, 1917, *Filaria lacrymalis* Marchi, 1860, *Filaria lacrymalis* Moroni, 1864, *nec* Dubini, 1850, *Spiroptera lacrymalis* Cobbold, 1874, *Filaria lacrymalis* Schneidmühl, 1896 (part).

*Hosts* —This is a widely-distributed parasite of the eyes

of horses. It seems probable that the records of its occurrence in cattle by some authors (*e. g.* Gaiger, 1910) may have been due to confusion with *T. rhodesi*. It has been recorded from horses in India by Lingard and by Gaiger, and a form which was probably this species is recorded from Ceylon by Nicholls and Crawford (1925).

The male measures 8–12 mm. in length and 0.3 mm in maximum thickness, the female 14–18 mm. and (according to Nicholls and Crawford) 0.37 mm respectively. The cuticular annulations are prominent, and are  $7\mu$  apart according to Travassos (1918), or  $20\mu$  according to Nicholls and Crawford. The buccal capsule is widest at its base,

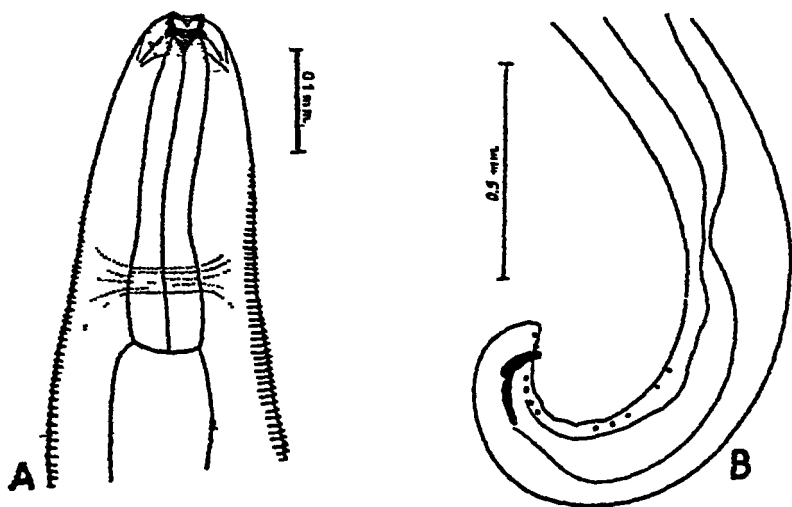


Fig. 93—*Thelazia lacrymalis*. A, anterior end of male; B, posterior end of male, lateral view. (After Travassos)

and measures about 0.01 mm in length and 0.021 mm. in width. The oesophagus is about 0.3–0.4 mm. long. The nerve-ring is situated at 0.2 mm. and the excretory pore at about 0.28 mm. from the anterior end.

The tail of the male is bluntly conical and measures 0.07 mm. in length. There are about 10–12 pairs of preanal and two or three pairs of postanal papillæ. Both spicules are stout and bear alæ distally. The left spicule is 0.17–0.19 mm long, the right 0.13–0.14 mm.

The tail of the female is 0.07 mm long, according to Nicholls and Crawford. The vulva is situated at 0.56–0.98 mm. from the anterior end.

### 3 *Thelazia callipæda* Railliet and Henry, 1910 (Fig 94)

Synonyms — *Filaria palpebralis* Houghton, 1917, *nec* Wilson, 1844; *Filaria circumocularis* Ward, 1918, ? *Filaria palpebralis* Pace, 1866; ? *Agamofilaria palpebralis* Castellani and Chalmers, 1910

*Hosts* — This species was originally recorded from a dog at Rawal Pindi, Punjab. It is reported to be common in

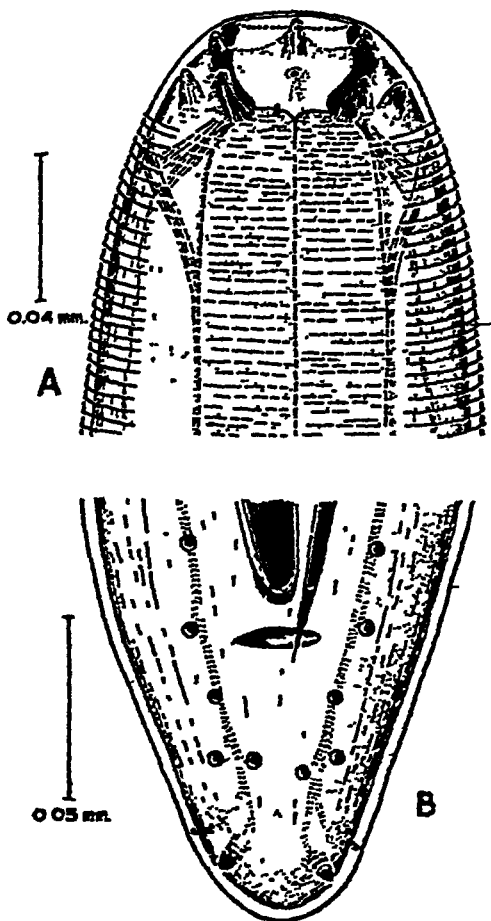


Fig 94 — *Thelazia callipæda* A, anterior end, lateral view; B, posterior end of male, ventral view. (After Hsü.)

dogs in Burma (Evans and Rennie, 1910) and in China, where several cases of human infestation have been recorded.

The original description has been largely supplemented by Faust (1928) and by Hsü (1933). The male measures about 4.5–13 mm. in length and 0.27–0.44 mm. in maximum

thickness, the female about 6.25-17 mm and 0.3-0.8 mm respectively. The cuticle is rather finely striated, but the edges of the striations are prominent. The head bears an inner circle of six small papillæ, and an outer circle consisting of two lateral and two pairs each of subdorsal and subventral papillæ. The buccal capsule measures about 0.02-0.033 mm. in length and 0.024-0.038 mm. in maximum width. It is cup-shaped, the greatest diameter being in the middle of its length, and the least at its posterior end. The œsophagus is about 0.5-0.86 mm. long. The nerve-ring is situated at about 0.27-0.47 mm. from the anterior extremity.

The tail of the male is blunt and measures 0.054-0.1 mm. in length. There are, according to Hsu, from eight to ten pairs of preanal and five pairs of postanal papillæ, all of which are subventral except the most posterior pair but one, which is laterally situated. The left spicule measures about 1.87-2.42 mm. in length, and has a pointed tip. The right spicule is about 0.12-0.16 mm. long, and is alate, with a blunt tip.

The tail of the female is bluntly conical and measures 0.045-0.094 mm. in length. The vulva is situated at about 0.37-0.67 mm. from the anterior end. The vagina, according to Faust, runs posteriorly for a distance of 1.4 mm. and then expands into a bulb. From this the common trunk of the uterus runs back for a distance of 0.7 mm. before giving off the uterine branches. The coils of the ovarian tubes extend almost as far as the anus. The embryos *in utero* measure about 0.4 mm. in length and 13.3-18  $\mu$  in thickness. According to Faust, the membranes in which they are enclosed swell up after their deposition in isotonic fluids, forming a balloon-like expansion at one end which causes them to float. They can also resist desiccation for several days.

#### 4 *Thelazia leesei* Railliet and Henry, 1910

Synonym —*Thelazia leesi* Neveu-Lemaire, 1912

*Host* —This species occurs in the eyes of camels, and was first found by Leese in the Punjab. Badanine (1938) has recorded it from Turkmenia.

The male measures about 12 mm. in length and 0.21 mm. in maximum thickness, the female 15-21 mm. and 0.4 mm. respectively. The cuticle is relatively finely striated. The buccal capsule is narrowed gradually anteriorly, but its walls are thickened posteriorly so as to reduce the lumen. In the female it measures, according to Badanine, 0.0125 mm. in length and 0.025 mm. in width at the base. The œsophagus is about 0.29 mm. long in the male and 0.32-0.36 mm. in the female. The nerve-ring is situated at about 0.2-0.28 mm. from the anterior end.

The male has at least 25 [pairs of ?] preanal papillæ. The spicules measure respectively 0.34 mm. and 0.105 mm.

The tail of the female, according to Badanine, is 0.07 mm. long. The vulva is situated at 0.425–0.44 mm. from the anterior end, according to Railhet and Henry, or at 0.63 mm. according to Badanine.

## 2 Genus *SPINITECTUS* Fourment, 1883

Synonyms —*Goezia* Zeder, 1800 (part); *Liorhynchus* Rudolphi, 1801 (part); *Cochlus* Zeder, 1803 (part)

Body armed with transverse rings, usually closer together anteriorly, bearing backwardly-directed spines. Head retractile, with inconspicuous lips. A short cylindrical or funnel-shaped buccal capsule present. Tail of male bluntly rounded, with narrow alæ. Caudal papillæ usually not more than about ten pairs, of which four or five are preanal. "Denticulate crests" sometimes present in front of the cloacal aperture. Spicules usually very unequal. Vulva in the middle or posterior region of the body. Uterine branches opposed. Female oviparous. Eggs (in the genotype) with polar filaments. Adult worms in the alimentary canal of fishes.

Genotype —*Spinitectus oviflagellus* Fourment, 1883.

### Key to Species.

- |   |                         |
|---|-------------------------|
| Male about 6 mm., female 9 mm. long, both spicules 0.11 mm. long                        | <i>indicus</i> , p. 172 |
| Male less than 2 mm. long, female undescribed; spicules about 0.4 mm. and 0.09 mm. long | <i>minor</i> , p. 171.  |
| Male undescribed, female less than 2 mm. long   | <i>corti</i> , p. 173.  |

## 1 *Spinitectus minor* (Stewart, 1914)

Synonym —*Spiroptera denticulata* [Rud.] var. *minor* Stewart, 1914

Host —*Wallago attu* (stomach); Lucknow

This form was described by Stewart (1914, a) from two male specimens only. It differs so greatly from the species now known as *Spinitectus inermis* (Zeder, 1800), of which the *Liorhynchus denticulatus*\* of Rudolphi is considered a synonym, that it is here treated as a distinct species.

The male measures 1.88 mm. in length and 0.068 ["0.68"] mm. in maximum thickness. The body is thickened anteriorly, and shows a series of prominent annulations, the edges of which, in the anterior third of the body, are armed with large spines, measuring up to about 0.024 mm. in length.

\* = *Spiroptera denticulata* (Rud., 1809) v. Lunstow, 1909

The first ring bears 26 spines, the second 22, and the third 20. The distance between the rings decreases from  $17\mu$  anteriorly to  $7\mu$  in the middle of the body. The mouth is at the apex of a conical structure, and there appear to be no lips. There is a tubular buccal capsule, about 0.03–0.048 mm. long. The œsophagus extends to a distance of about 0.13–0.2 mm from the head end. It is "broadest at its anterior extremity, where it expands like the capital of a pillar, and decreases steadily in its first third. The second two-thirds are uniformly cylindrical. Before joining the intestine it forms one complete loop by curling upon itself." The nerve-ring and excretory pore were not seen.

The tail is 0.059–0.068 mm. long. The caudal alæ begin at a distance of 0.277 mm from the posterior extremity. There are from four to six preanal and from five to six postanal papillæ on each side. The left spicule is about 0.44 mm long, and has a "foot-shaped" terminal portion measuring 0.015 mm in length. The right spicule is pointed and about 0.08–0.094 mm long.

## 2 *Splinitectus indicus* Verma and Agarwala, 1932 (Fig. 95)

*Hosts*.—Siluroid fishes—*Pseudotropius garua*, *Eutropichthys vacha* (intestine, often attached to the wall and usually in the hinder part), Allahabad.

The male measures, on an average, 6 mm in length and 0.11 mm in maximum thickness, the female 9 mm. and 0.39 mm. respectively. The cuticle of the body bears more than 150 spiny annulations, the anterior 20–30 of which are conspicuous. The annulations grow less marked posteriorly, and disappear near the anus. The distance between them gradually increases posteriorly, but behind the anterior third of the body they become almost equidistant. The number of spines on each annulation is 22–28, and their length about  $25\mu$  in the male and  $23.5\mu$  in the female. The mouth is "bounded by four inconspicuous papillæ or valves." The buccal capsule is narrow and tubular, and measures 0.3 [0.03] mm in length. The œsophagus is 1.5 mm long, and is narrow anteriorly, but widens to a diameter of 0.12 mm. near its posterior end. The nerve-ring, in the female, is situated at 0.19 mm from the anterior extremity.

The tail of the male is slightly bent, and measures 0.16 mm in length. There are nine pairs of caudal papillæ, of which five are preanal and four postanal. They decrease in size posteriorly. The spicules are said to be equal in length (0.11 mm) and similar in shape. "The anterior part is rod-like and outwardly inclined, almost at right angles to the main axis; but the main body is somewhat depressed and

bears, about its middle, a minute tubercle along the outer margin "

The tail of the female is 0.2-0.3 mm long, and has a pointed tip. The vulva is slightly in front of the middle of the body. The vagina is a narrow muscular tube, running posteriorly from the vulva. The uterine branches are reflexed, the anterior branch doubly

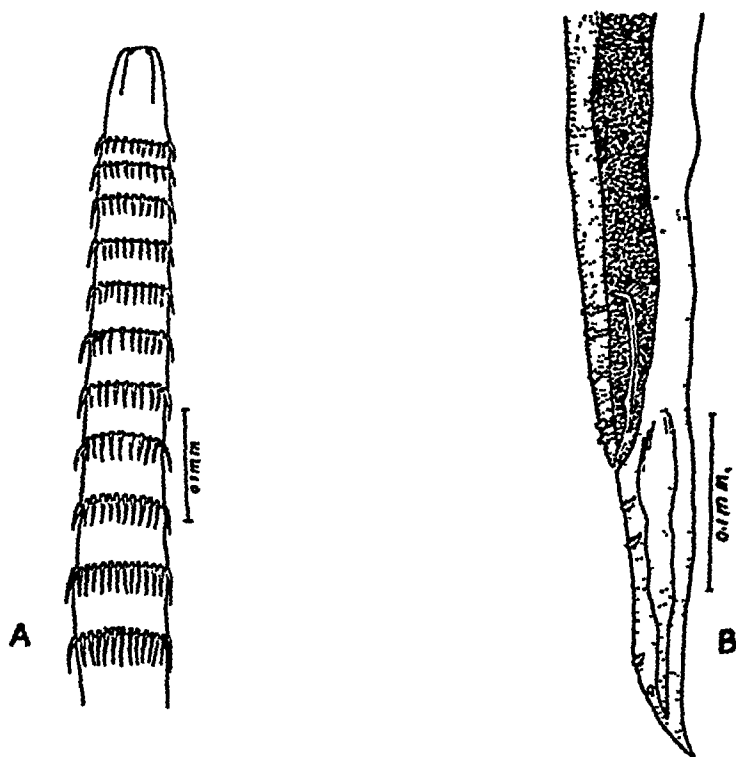


Fig 95—*Spinitectus indicus* A, anterior end of male; B, posterior end of male, lateral view (After Verma and Agarwala)

### 3 *Spinitectus corti* Moorthy, 1938

*Host* —*Ophrocephalus gachua* (intestine), Chitaldrug District, Mysore State

Of this species Moorthy (1938, a) obtained only females. These measured 1.4-1.9 mm in length and 0.14-0.18 mm in maximum thickness. The body tapers slightly towards both ends, and bears 45-51 rings of prominent spines, beginning at about 0.07 mm from the anterior extremity. The first two rings are closer together than the rest. The number of spines increases from 22 in the first ring to about 30 in the rings near the middle of the body, and then decreases

gradually to about six in those near the tail, which are not complete circles. There is a short, funnel-shaped mouth, leading into a narrow, tubular buccal capsule. The anterior portion of the œsophagus is 0.13–0.14 mm long, the posterior portion 0.28–0.37 mm. The nerve-ring is situated at 0.12–0.14 mm. from the anterior extremity, and the excretory pore at the level of the fourth ring of spines.

The tail is 0.1–0.13 mm long, and bears a pair of caudal papillæ not far from its tip, which may be acute or rounded. Spines may or may not extend to the tip. The vulva is situated in the posterior third of the body, at 1.23–1.6 mm from the anterior end. The muscular vagina runs forward for a distance of about 0.18 mm from it, and the uterine branches extend anteriorly to the middle of the posterior portion of the œsophagus. The eggs measure 0.028–0.031  $\times$  0.016–0.018 mm, and are said to be without polar filaments.

### 3 Genus *THYLACONEMA* Chandler, 1929.

Cuticle (in female) with coarse annulations, the edges of which are armed with numerous backwardly-directed spines. Buccal capsule with a wide, cup-shaped anterior portion and a narrow posterior portion. [Male\* with broad caudal alæ and several pairs of pedunculate preanal and postanal papillæ. Spicules unequal, both relatively long and slender. An accessory piece present.] Vulva in the œsophageal region. Uterine branches parallel. Adult worms in the peritoneal cavity of birds.

Genotype :—*Thylaconema sigmura* Chandler, 1929.

#### 1. *Thylaconema sigmura* Chandler, 1929 (Fig 96)

*Host* :—Argus pheasant (*Argusianus argus*) (peritoneal cavity); Zoological Gardens, Calcutta.

The female measures about 15 mm in length and 0.4 mm in maximum thickness. The diameter of the head is about 0.065 mm. The cuticular annulations are about 12  $\mu$  apart in the œsophageal region, the interval increasing to 25–30  $\mu$  in the posterior part of the body. They are armed with small spines, which are most marked in the anterior half of the body. The anterior portion of the buccal capsule measures about 0.025 mm in width and 0.015 mm. in depth. The œsophagus is about 0.88 mm long, and has an almost uniform diameter of about 0.055 mm. The nerve-ring is situated at about 0.45 mm. from the anterior end.

\* The male specimen described by Chandler was incomplete, and he expresses some doubt as to whether it belonged to the same genus and species as the female.

The intestine is of the same diameter as the oesophagus, from which it is very indistinctly marked off. The posterior end of the body is curved S-wise. The tail is curved tentrally, finger-like and almost cylindrical, with a blunt tip, and measures 0.155 mm in length. The anus

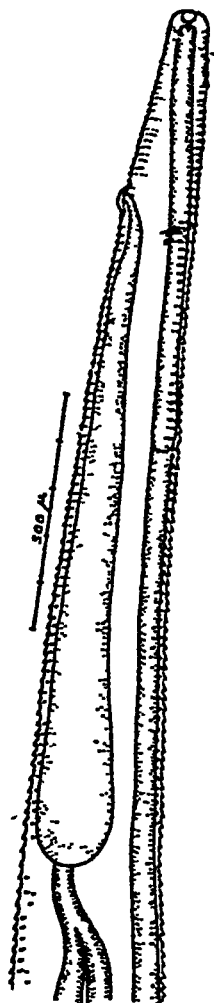


Fig 96—*Thylaconema sigmura* Anterior end of female; lateral view. (After Chandler)

and vulva are somewhat prominent. The latter is situated at 0.39 mm from the anterior extremity. The vagina forms an elongate sac, about 1.4 mm long and widening gradually to a diameter of 0.155 mm. posteriorly. The common trunk

of the uterus is very short and about 0.035 mm in diameter. The uterine branches narrow suddenly in the posterior region of the body, and end in slightly coiled ovaries.

[The single male seen by Chandler was without its anterior end, and it could not, therefore, be determined whether it belonged to the same species, or even genus, as the female. Its characters, as described and figured, seem suggestive of *Habronema* rather than of a member of the *Thelazunæ*, especially as regards the caudal alæ, papillæ, spicules and accessory piece. The maximum thickness of this specimen is 0.27 mm. The tail is 0.175 mm long. The caudal alæ form a spoon-shaped structure measuring 0.4 mm in length and about 0.3 mm in width, marked with fine striations. There are two pairs of lateral preanal papillæ with long peduncles, an adanal pair and two postanal pairs of similar papillæ, and three or possibly four pairs of smaller papillæ near the tip of the tail. The longer spicule, which is apparently that of the right side, measures 1.35 mm in length, the shorter 0.59 mm. The accessory piece consists of "two convergent chitinized bars connected by a delicate membrane."] ]

#### 4 Genus *RHABDOCHONA* Railliet, 1916

Synonyms — *Dispharagus* Dujardin, 1845 (part), *Histioccephalus* Diesing, 1851 (part), *Pseudancyracanthus* Skrjabin, 1923 (part), ? *Ichthyosporura* Skrjabin, 1917.

Lips small. Buccal capsule funnel-shaped anteriorly, and supported in this region by longitudinal ribs, which project as teeth anteriorly. Tail of male conical, without alæ. Numerous preanal and five or six pairs of postanal papillæ present. Spicules unequal. Vulva in middle region of body. Uterine branches opposed. Adult worms usually in the intestine of freshwater fishes.

Genotype :—*Rhabdochona denudata* (Dujardin, 1845)

#### 1 *Rhabdochona uca* Pearse, 1932

Host — Fiddler crab (*Uca manii*) (intestine), Port Canning.

This species is tentatively assigned by Pearse to the genus *Rhabdochona*. The male is unknown. The following is Pearse's description :—

"Body length of female : 1.2 mm, width, 0.03 mm. Lips with three teeth; buccal cavity supported by eight longitudinal thickenings; muscular œsophagus, 0.24 mm. long, glandular œsophagus, 0.22 mm. long. Tail 0.14 mm. long, tapering, obtuse. Uteri apparently opposed, anterior one showing eggs increasing in size posteriorly; vulva near middle of body."

5 Genus **QUASITHELAZIA** Maplestone, 1932 \*.

Conical lips present, surmounted by cuticular caps. Buccal capsule elongate, thick-walled, cylindrical, but expanded dorso-ventrally in front. Male with well-developed caudal alæ and numerous small caudal papillæ. Spicules unequal and dissimilar. Accessory piece absent. Female undescribed. Adult worms in the gizzard of birds.

Genotype.—*Quasithelazia tenuis* Maplestone, 1932.

1 *Quasithelazia tenuis* Maplestone, 1932 (Fig 97.)

Host.—Kingfisher (*Halcyon* [*Ceryle*] *smyrnensis*) (gizzard); Zoological Gardens, Calcutta

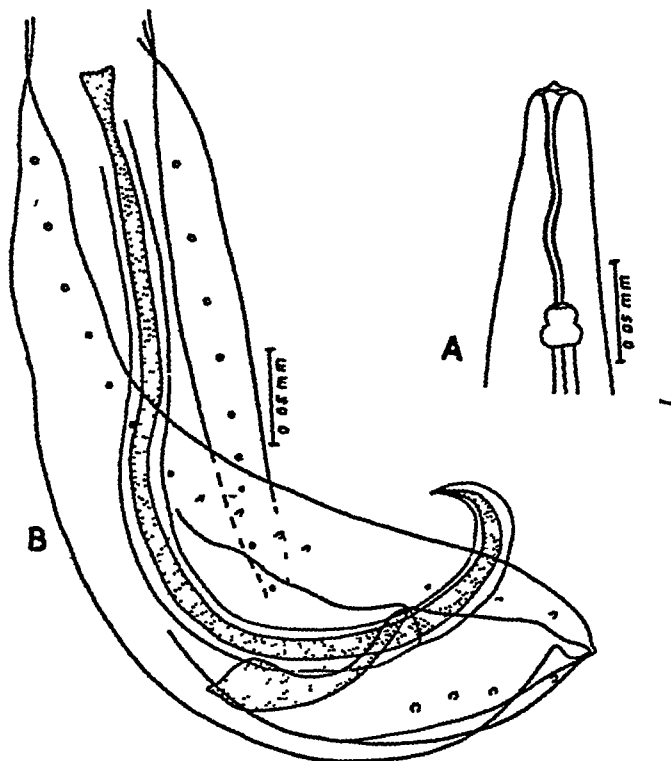


Fig. 97—*Quasithelazia tenuis*. A, anterior end, B, posterior end of male, ventro lateral view. (After Maplestone)

This species is known only from a single male specimen

\* The systematic position of this genus is very doubtful. Maplestone places it in the Schistorophinae of Travassos, 1918, a group which is itself of doubtful status. He points out, at the same time, that the genus has resemblances both to the Acuarinae and to the Thelazinae. It is here placed provisionally in the latter group.

This measured 8.48 mm. in length and 0.12 mm. in maximum thickness. The length of the buccal capsule was 0.16 mm. that of the anterior portion of the œsophagus 0.396 mm. and that of its posterior portion 0.931 mm. Between the buccal capsule and the œsophagus "there is a swollen, slightly lobate structure, which is probably glandular in function."

The caudal end is curved ventrally. The tail is 0.1 mm. long. There are twelve pairs of preanal and four pairs of postanal papillæ. The papillæ are said to be pedunculate, but Maplestone's figure does not indicate this. The spicules measure 0.54 mm. and 0.11 mm. in length respectively.

### Subfamily RICTULARIINÆ Hall, 1913\*.

Lips absent. Mouth subterminal, opening dorsally by a transversely elongated aperture bordered with small denticles. A small, well-cuticized buccal capsule present, armed at its base with teeth or spines. Cuticle of body armed with two longitudinal subventral rows of large, flattened, comb-like spines, at least in the anterior region, the spines becoming scarcer and smaller posteriorly. Œsophagus simple and club-shaped. Caudal end of male conical, with or without somewhat bursa-like alæ. Several pairs of preanal and postanal papillæ present. Spicules short, equal or subequal. An accessory piece present. Vulva near the posterior end of the œsophagus. Uterine branches parallel, running posteriorly. Females oviparous. Eggs contain embryos when laid. Adult worms in the small intestine of carnivores, bats and rodents.

### 1 Genus RICTULARIA Frolich, 1802

Synonyms — *Ophiostoma* Rudolphi, 1801 (part), *Ophiostomum* Creplin, 1839 (part), *Laphyctes* Dujardin, 1845, *Pterygodermatites* Wedl, 1861, *Diserratosomus* Mirza, 1933.

With the characters of the subfamily

Genotype — *Rictularia cristata* Frolich, 1802

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\* Hall (1913) regarded *Rictularia* as belonging to the Strongyloidea, and placed it, with *Rictularioides*, in a subfamily of the Metastrongylidæ. There can be no doubt, however, of its Spirurid affinities. Baylis and Daubney (1926) placed it in an appendix to the Thelazuinæ, while Yorke and Maplestone (1926) adopted the family Rictulariudæ of Railliet, which they placed among the Spiruroidea. The writer is unable to accept the family Rictulariudæ as a natural group, but feels that the peculiar characters of *Rictularia* mark it off quite distinctly from the Thelazuinæ. Hall's subfamily is therefore retained in a restricted sense, redefined so as to include only *Rictularia*, and transferred to an entirely different position in the system.

Parasite of carnivores  
Parasite of squirrel

## Key to Species

*cahrensensis*, p 179  
*elvaræ*, p 181

1. *Rictularia cahrensensis* Jägerskiöld, 1904 (Figs 98 & 99)

*Hosts*:—This is a parasite of cats and dogs. It was originally recorded from Egypt by Jägerskiöld, and is known to occur also in Turkestan, Bokhara and Armenia (Massino, 1925). Vevers (1923) has recorded it from the South American Azara's fox (*Canis azaræ*) in the London Zoological Gardens. In India it has been recorded from a civet (*Viverricula malaccensis*) by Baylis and Daubney (1923, b).

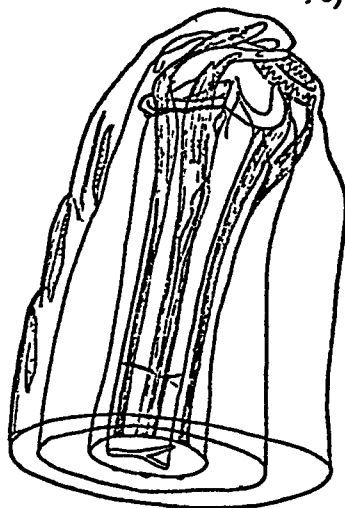


Fig 98—*Rictularia cahrensensis* Anterior end, lateral view.  
(From Baylis, after Jägerskiöld)

The male measures about 3.7–6.8 mm in length and 0.18–0.38 mm in maximum thickness, the female about 8.8–19.6 mm and 0.24–0.46 mm respectively. The male has 95 or 96 pairs of subventral "combs," extending almost as far as the cloacal aperture. The last two pairs are larger than the others. The female has 46–52 pairs of prevulvar "combs" and 78–87 pairs of postvulvar "combs" or spines, extending to within 1.2–2 mm of the posterior end. The male has, in addition, a row of seven or eight mid-ventral "combs" or "fans" in front of the cloacal aperture. The cuticle, according to Jägerskiöld, is thickened dorsally for a short distance behind the head-end. According to Massino there is a dorsal ala, beginning a little behind the anterior end and extending throughout the anterior third of the

oesophageal region. The mouth is bordered internally with conical denticles, except on the ventral side. The buccal capsule has a maximum width (at its base) of 0.048 mm. dorso-ventrally, or 0.042 mm laterally. Its floor is flat or slightly convex. The ventral wall of the capsule is more than twice as long as the dorsal wall. A large dorsal and two smaller subventral teeth project forward into the capsule from its floor. The dorsal tooth, according to Jägerskiöld, has a large median cusp and two very small accessory cusps. The oesophagus is 0.95–1.71 mm long in the male, and 2–3.71 mm. in the female. Its wider posterior portion is about six times as long as the narrower anterior portion.

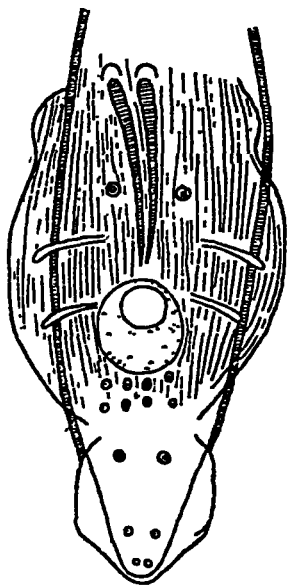


Fig. 99 — *Rictularia cahirensis* Posterior end of male ;  
ventral view (After Massino )

The nerve-ring is situated at about the middle of the anterior portion, and the cervical papillæ a little behind the junction of the two portions and at the level of the twelfth pair of "combs" (at about 0.21 mm from the anterior end in the male, or 0.37–0.68 mm in the female). The excretory pore is about half-way between the nerve-ring and the junction of the two parts of the oesophagus (at about 0.1 mm from the anterior end in the male, or 0.24–0.29 mm in the female).

The tail of the male is about 0.13–0.24 mm long. There are two pairs of caudal alæ, the anterior pair large and longitudinally striated, the posterior pair smaller and bordering the tip of the tail. There are ten pairs of caudal papillæ, of which three are preanal and seven postanal. They are

arranged, according to Massino, as shown in fig. 99. According to Jägerskiöld the most anterior pair, like the two following pairs, have long peduncles. According to Massino they are sessile. The cloacal aperture is situated on a prominence covered with minute spine-like elevations. The spicules are equal and measure about 0.17–0.19 mm in length. They have rounded roots and pointed tips. The accessory piece, according to Massino, is slipper-shaped.

The tail of the female is about 0.14–0.2 mm long, and ends in a small spike, near the base of which there is a pair of very small papillæ. The vulva is situated at about 2.2–3.9 mm from the anterior extremity. The vagina runs posteriorly and, after a course of about 0.4 mm, gives off the two uterine branches. The eggs measure about 0.039–0.043 × 0.026–0.034 mm.

## 2 *Rictularia elviræ* Parona, 1889 (Fig 100)

*Host*.—Red-cheeked squirrel (*Dremomys* [*Sciurus*] *rufigenis*) (intestine), Mt. Mooleyit, Dana Mts, Tenasserim.

Of this species the male is unknown. The female measures 39–47 mm in length and 1.25 mm in thickness. According

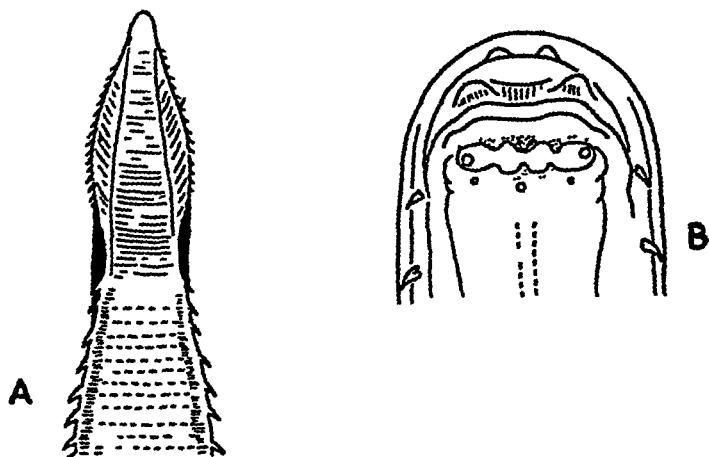


Fig 100.—*Rictularia elviræ*. A, anterior end of female, dorsal view; B, anterior extremity of female, dorsal view, more highly magnified. (After Parona.)

to Parona (1889, b) there are 19 pairs of small spines in the cervical region, followed, after a short interval, by a second series of 32 pairs, increasing in size and becoming more widely separated posteriorly, and extending to within 8.5 mm of the posterior extremity. According to Jägerskiöld (1909), however, who re-examined the type-specimens but adds nothing

else to the original description, there are 26 [pairs of] "combs" and 32 [pairs of] spines. The mouth has a transverse diameter of "0.014" [0.014] mm, and has three projections on its anterior and three on its posterior border. Within the buccal capsule there are also two rounded papilliform projections. The oesophagus is short and is said to measure "0.021" [0.021] mm in thickness. There is a pair of lateral cervical alæ, beginning a short distance from the anterior end and measuring about 1.5 mm in length. The cervical papillæ are situated at about the anterior third of the alæ.

The vulva is situated between the first and second series of "combs" or spines. The eggs measure  $0.056 \times 0.028$  mm.

### 3 *Rictularia* sp

Baylis and Daubney (1922) record a single female specimen of an undetermined species of *Rictularia* from the intestine of a palm-civet (*Paradoxurus hermaphroditus bondai*) caught in the Museum compound, Calcutta.

### 4 *Rictularia* sp

Synonym — *Diserratosomus mungoosii* Mirza, 1933.

Host — Mongoose (*Herpestes mungo*) (intestine), India.

Mirza (1933) describes a specimen which was evidently the anterior portion of a *Rictularia*. This fragment measured 8.9 mm. in length and 0.253 mm in maximum thickness, and showed 42 pairs of "corns" or spines.

### *Rictularia* sp

Rahimullah and Das (1933) record three female specimens of an undetermined species of *Rictularia* from the intestine of a Russell's viper (*Vipera russellii*) in the Deccan. These were probably "pseudoparasites" derived from some animal swallowed by the snake.

## SPIRURIDÆ OF UNCERTAIN POSITION

("Spiroptera," sens lat.)

Under this heading are placed certain species which have not been described in sufficient detail to enable their systematic position to be determined. The name *Spiroptera* (sensu stricto) is a synonym of *Acuaria*, and is therefore invalid as a generic name. It may, however, conveniently be used, as it has been used by many authors, to designate any Spirurid of uncertain status.

1 "*Spiroptera*" *feai* Stossich, 1897

*Host* —Hawk-owl (*Ninox scutulata*) (orbital cavity), Bhamo, Burma

This species was erected by Stossich for a worm described under the name of "*Spiroptera* sp" by Parona (1889, *b*). According to Parona, the single female specimen examined by him measured 16 mm in length and 1 mm in thickness. The head had a rounded outline and two conical papillæ, measuring 0.018 mm in length. The tail was very blunt, with a short prominence but without a terminal spike.

2. "*Spiroptera*" *triangulum* v Linstow, 1904

*Host* —*Calotes ophiomachus* (body-cavity), Colombo, Ceylon

Of this species the type-specimen does not appear to be available in the Colombo Museum. v Linstow (1904) describes the worm as follows —

"One male specimen, 4.1 mm long, 0.51 mm broad, cuticula annulate, at the junction of œsophagus and intestine there is a deep circular constriction of the body wall.

"The head is rounded, and presents on each side a triangular mark with a small papilla at the apex, the mouth leads into a small vestibule, the spicula (cirri) are sub-equal and measure 0.41 mm, they are attenuated and pointed at the end, and show externally a reticulate design, the œsophagus is equal to  $\frac{1}{77}$ , the tail to  $\frac{1}{153}$  of the entire length; the tail is flattened dorsally, on each side of it are four præ-anal and two post-anal papillæ, the former increase in size from before backwards, and the first post-anal papillæ are finger-shaped."

The figure given by v Linstow of the posterior end is somewhat suggestive of *Strongyluris*, though from the description it does not appear possible to identify the worm with *S. calotis* Baylis and Daubney, 1923 (see vol 1, p 145). In any case, it is probably not a Spirurid.

3 "*Spiroptera*" *secretoaria* v Linstow, 1906

*Host* —Indian darter (*Anhinga* [*Plotus*] *melanogaster*) (œsophagus and stomach), Wirawila, Ceylon

The type-specimens of this species do not appear to be available in the Colombo Museum. v Linstow's (1906, *d*) description is as follows —

"Dimensions up to 32×16 [mm], but all specimens immature, both ends strongly attenuated, cuticle annulate, some are larvæ in process of exuviation. At the head a dorsally placed obtusely conical papilla, in a circle behind

this are six roundish papillæ, and behind these in the submedian lines four truncate papillæ with a very small one at the inner side. Alongside the œsophagus runs a long gland containing a long granular secretion often projecting through the orifice which lies close behind the papillæ. Tail short with small finger-shaped appendix, lateral lines strongly developed, one-fifth of the diameter of the body, enclosing a lateral canal."

Apart from the prominent cone projecting anteriorly, v Linstow's figure of the head of this species is somewhat suggestive of *Habronema*.

#### 4 "Spiroptera" spp

v Linstow (1904) mentions under the name of "*Spiroptera* spec ?" an immature form from the peritoneum of *Bufo melanostictus* at Colombo, Ceylon. This measured 35 mm in length and 1.18 mm in thickness.

Undetermined species of "*Spiroptera*" are also mentioned, without description, by v Linstow (1906, d) from the intestine of the long-tailed robin (*Kittacincla malabarica* [= *Cittacincla macroura*]) at Nedunkeni, from the œsophagus of *Pavo cristatus* at Buttawa; and from the peritoneum of *Funambulus* [*Sciurus*] *palmarum* at Colombo, all these localities being in Ceylon.

### 4. Family GNATHOSTOMIDÆ Raillet, 1895.

Lips large, trilobed, having the cuticle of their inner surfaces thickened and usually raised into longitudinal tooth-like ridges which meet or interlock with those of the opposite lip. No pharynx or buccal capsule. The vagina runs forward from the vulva. Uterine branches two or four. Females oviparous. Eggs with thin shells, ornamented with fine granulations. Adult worms in the alimentary canal of vertebrates, usually attached to or burrowing in its walls.

#### Subfamily GNATHOSTOMINÆ Baylis and Lane, 1920.

Lips followed by a cuticular head-bulb provided either with prominent transverse striations or with transverse rows of backwardly-directed hooks, and containing four membranous submedian "ballonets," the cavity of each of which is in communication with one of four elongated, blind cervical sacs which run back parallel to the œsophagus.

## Key to Genera.

Head bulb not armed with hooks	TANALA, p 198
Head bulb armed with rows of hooks	1
1 Body unarmed	1 CHINOCIPHALUS p 191
Body armed with spines	GNATHOSTOMA p 185

## 1 Genus GNATHOSTOMA Owen, 1836

Synonyms — *Cheiracanthus* Diesing 1839, *Cheiranthus* v. Lanstow, 1893, *Cheiracanthus* Schenckemühl 1896, *Gnathostomum* Mitter, 1912

Head-bulb armed with transverse rows of hooks, and showing no external evidence of the presence of the "ballonets." No cuticular collar behind the head-bulb. Body armed with numerous transverse rows of backwardly-directed cuticular spines. Anteriorly these spines are scale-like and have their free edges denticulate, posteriorly they become gradually less subdivided and ultimately simple. Caudal end of male with slight alae. Four pairs of large lateral papillae and two or more pairs of small subventral papillae present. Spicules unequal. Vulva behind the middle of the body. Uterine branches two. Adult worms in the stomach-wall of mammals.

Genotype:—*Gnathostoma spinigerum* Owen, 1836

## Key to Species

Spines present only on the anterior two-thirds of the body	<i>spinigerum</i> , p 185.
Spines present throughout the body	1
1 Longer spicule of male less than 1.5 mm long, shorter spicule up to 0.4 mm, eggs with wart-like cap at one pole	<i>longulum</i> , p 188
Longer spicule of male more than 1.5 mm long, shorter spicule 0.6-0.7 mm, eggs with wart-like caps at both poles	<i>dolorem</i> , p 190

1 *Gnathostoma spinigerum* Owen, 1836 (Figs 101 & 102)

Synonyms — *Cheiracanthus robustus* Diesing (1838) 1839, *Cheiracanthus socialis* Leidy 1859, *Falaria radula* Schneider, 1866, *Cheiracanthus mameus* Levensen 1889, *Gnathostoma japonica* Porta, 1908, *Gnathostomum spinigerum* Mitter, 1912

Hosts — The normal hosts of the adults of this species are carnivores of the families Felidae, Canidae and Mustelidae. It has been recorded from many oriental countries, from North and South America and from Australia. Its Indian hosts include the tiger, leopard and domestic cat. Thwaite (1927) records it from "*Felis tigrinum*"\* at Colombo, Ceylon, and

\* *Felis tigrina* is a South American species, and is not indigenous to Ceylon.

there are specimens in the British Museum (Natural History) from a dog from Rangoon, Burma. Immature forms, probably belonging to this species, have been recorded on several occasions as accidental parasites of man in Siam, the Malay States, China and Japan, while Maplestone (1929, e) records a similar case in India.\* The parasite has, in these human cases, been found in the subcutaneous tissue, sometimes in tumours or abscesses. In its final hosts the worm burrows in the wall of the stomach, where it causes the formation of dense tumours. These may ultimately open into the abdominal cavity, and the death of the host from peritonitis not infrequently results. Each tumour may contain one or several worms. Chandler (1925, b) found such tumours fully formed in eleven out of thirty-five cats examined in Calcutta between August and November, but none in 156 cats examined from November to February. From January to April only

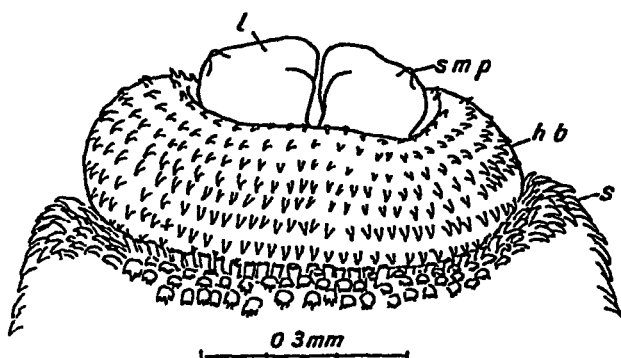


Fig 101—*Gnathostoma spinigerum*. Anterior end, dorsal view  
hb, head-bulb; l, lip, s, spines on body, smp, submedian papilla (After Baylis and Lane, in Proc Zool Soc)

immature worms, as a rule, were found, and these were usually burrowing in the liver, peritoneum, mesentery or diaphragm. Chandler concludes that the incidence of the parasite in cats is seasonal, and that it is "consistently lethal" to them.

The male measures about 10–25 mm in length and 1–1.9 mm in maximum thickness, the female 9–31 mm and 1–2.5 mm respectively. The lips have a dorso-ventral diameter of 0.13–0.25 mm. The cuticular lining of the inner aspect of each lobe of the lips is thickened to form a longitudinal ridge which meets its fellow of the opposite side. The head-bulb

\* Maplestone suggests that the worm in this case was not *G. spinigerum* but a different species. It does not seem clear from his description, however, that it differed specifically from the forms from man described by other authors, or from the larvae found in snakes and other vertebrate intermediate hosts. A constant feature of these larvae is that the head-bulb bears only four rows of hooks, while the development and distribution of the body-spines appear to vary, probably with the age of the larvae.

has a transverse diameter of about 0.45–0.6 mm, and bears from six to eleven rows of hooks. These measure 0.015–0.025 mm in length. The body is covered for about the anterior two-thirds of its length with flattened spines, the more anterior of which end in three or four denticulations. In the oesophageal region the spines have three points, of which the median is usually longer than the others. Behind the oesophagus the spines become two-pointed, and towards the middle of the body single-pointed. The more posterior spines become gradually shorter, so that they are ultimately reduced to mere points protruding beyond the striations of the cuticle. The oesophagus extends to a distance of about 3.1–4 mm from the anterior extremity, and the cervical sacs to 1.8–2 mm. The nerve-ring is situated at about 0.5 mm, and the cervical papillæ at 0.7–0.75 mm, from the anterior end.

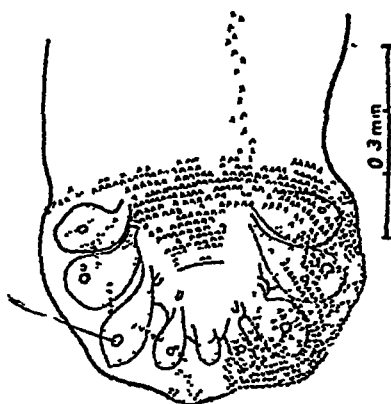


Fig 102—*Gnathostoma spinigerum*. Posterior end of male, ventral view. (On the left hand side of the drawing most of the spines have been omitted.) (After Baylis and Lane, in Proc Zool Soc.)

The caudal end of the male is surrounded by an alar expansion, and the ventral surface in the alar region is covered, except for a Y-shaped central area, with transverse rows of small spines. The cloacal aperture is situated at the fork of the "Y". The tail is about 0.22 mm long, and ends in a blunt, papilla-like process which does not project beyond the alar expansion. The four pairs of large lateral papillæ have swollen peduncles. Two pairs are preanal and two postanal. The most posterior papilla on each side is the smallest. Near the bases of this and the next pair there are two pairs of small, sessile, subventral papillæ. The left spicule measures about 1.1–2.6 mm in length, the right 0.4–0.8 mm. The former is somewhat narrowed in its middle third, while the latter is

narrowed for the greater part of its distal half. The left spicule ends in a small hyaline knob.

The tail of the female is blunt and measures about 0.15 mm in length. It bears a pair of large lateral papillæ. The vulva is situated at 4–8 mm from the posterior end. The muscular vagina runs in a generally anterior direction from it, and is very long, extending as far as the posterior end of the oesophagus, where it turns posteriorly again. The eggs measure up to  $0.06 \times 0.035$  mm\*. Their shells are provided with a thin cap at one pole.

From the researches of Prommas and Daengsvang (1933, 1936, 1937), Yoshida (1934), Africa, Refuerzo and Garcia (1936, a & b) and Yoshida, Onohara and Tomiha (1936) it appears that the life-history of *G. spinigerum* involves two intermediate hosts, the first of which is a Copepod crustacean (*Cyclops*), the second a freshwater fish, frog or snake. *Clarias magur* [= *C. batrachus*] and *Ophiocephalus striatus*, both Indian fishes, were infected experimentally by Prommas and Daengsvang, who were also able to infect cats by feeding them with these fishes. *Glossogobius giurus*, *Therapon argenteus*, the goldfish, the "green frog" and a snake (*Hurria rhynchops*) are among the second intermediate hosts recorded by the other authors in the Philippines and Japan. Chandler (1925, c) found larval forms of *Gnathostoma* encysted in the mesentery of snakes (*Python reticulatus*, *Naja hannah* [= *N. bungarus*], *N. tripidians*) in the Zoological Gardens, Calcutta. These larvæ underwent some development in experimentally-infected cats, but no fully adult worms appear to have been recovered. Chandler therefore did not attribute the larvæ definitely to *G. spinigerum*, but expressed the opinion that they were identical with *G. pelecani* (Chatin, 1874), a larval form recorded from the pelican. In the light of more recent work, however, it seems not improbable that they were larvæ of *G. spinigerum*. The same observation applies to a larva described by Pearse (1932) from a cyst in the mesentery of *Saccobranchus fossilis* at Calcutta.

## 2. *Gnathostoma hispidum* Fedchenko, 1872 (Fig 103)

Synonyms — *Gnathostoma hispidum* *sus* Csokor, 1882. *Cheiracanthus hispidus* Csokor, 1882, *Cheiranthus hispidus* Linstow 1893, *Gnathostoma hispidum* Bhalerao, 1935.

*Hosts* — This species was originally described by Fedchenko from the wild boar (*Sus sciofa ferus*) in Turkestan and from the domestic pig in Hungary. It was subsequently recorded from pigs in Hungary and Rumania, and redescribed, by

\* Tang (1936) gives the dimensions of the eggs as  $0.0591-0.0862 \times 0.0422-0.0455$  mm.

Csokor (1882), v. Linstow (1893), v. Rátz (1900), and Ciurea (1911, b). It has also been found in swine in Austria, French Indo-China, India and China, and there are specimens in the British Museum (Natural History) from a wild boar (*Sus cristatus*) from Ceylon. This parasite, like *G. spinigerum*, burrows in the wall of the stomach of its normal hosts, causing the formation of cavities containing blood-stained fluid. Immature specimens attributed to this species have occasionally been recorded as "erratic" parasites in the subcutaneous tissue of man in China and Japan.

The male measures about 15–25 mm in length and 1.2–2 mm in maximum thickness, the female about 22–45 mm and 1.8–2.5 mm respectively. In the fresh condition the anterior portion of the body is blood-red. The head-bulb measures up to 0.75 mm in transverse diameter, and bears from nine to twelve rows of hooks. The entire body is covered with spines. The most anterior of these have from seven to nine subequal points. More posteriorly a median point tends to become longer than the others, which gradually disappear, the spines becoming simple at about the level of the posterior



Fig 103.—*Gnathostoma hispidum*. Spines from cesophageal region (After v. Rátz)

end of the cesophagus, which is about 3.4–5.5 mm from the anterior extremity. The cervical sacs extend back to a distance of 0.7–0.88 mm from the anterior end.

The tail of the male is about 0.3 mm long. Its tip, as in *G. spinigerum*, resembles a terminal papilla. Of the four pairs of large lateral papillæ, according to Ciurea, the most posterior are the smallest and are separated by an interval from the other three pairs, which lie close together and are of about the same size. Fedchenko figures one pair of sessile subventral papillæ between the bases of the two posterior pairs of lateral papillæ. v. Linstow omits these, but describes a pair in front of the cloacal aperture, while Ciurea finds five pairs of sessile papillæ, two in front of and three behind the cloacal opening. The left spicule measures 0.88–1.29 mm in length, the right 0.32–0.4 mm.

The tail of the female is about 0.3 mm long. The vulva is situated in the middle region of the body, but its position appears to be rather variable. The eggs measure about  $0.072\text{--}0.074 \times 0.039\text{--}0.042$  mm, and have a wart-like cap at one pole.

### 3 *Gnathostoma doloresi* Tubangui, 1925 (Fig 104)

*Host* —Like the last species, this is a parasite of swine. It was first recorded from the domestic pig in the Philippines. Maplestone (1930, *a*) records it as being present in eleven out of forty-nine pigs examined in Calcutta. According to Tubangui (1925) only the head of the worm is buried in the gastric wall, but Maplestone says "the worms cause extensive damage to the stomach wall, in which they burrow deeply."

Tubangui had only female specimens at his disposal, but Maplestone obtained both sexes, and gives a fuller description. He found considerable variation in the size of the worms. The extreme measurements given by both authors are included in the following description.

The male measures 19.7–38 mm in length and 1.1–2.6 mm in maximum thickness, the female 27–52 mm and 1.46–4.9 mm

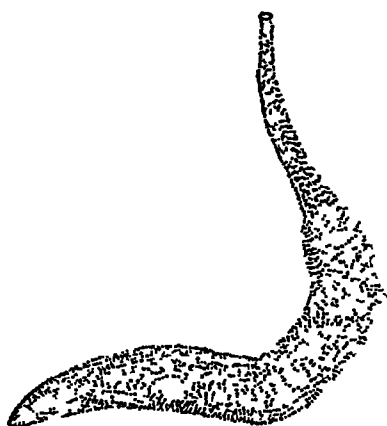


Fig 104 —*Gnathostoma doloresi* Female ( $\times 3$ ) (After Tubangui)

respectively. The cuticle of the posterior two-thirds of the body is considerably inflated, so that the anterior third appears much more slender. The head-bulb measures about 0.32–0.46 mm in length and 0.63–1 mm in transverse diameter. It bears ten rows of hooks. The entire body is covered with spines. The most anterior two or three rows, according to Maplestone, contain spines with three or four points. Posteriorly to these the number of points on the spines increases gradually but irregularly, reaching a maximum of six or seven subequal points at about the level of the cervical papillæ (i.e. in the 15th to 18th rows of spines). Behind this level the spines again become three-pointed, the median point being longer than the others. The outer points, more posteriorly still, gradually diminish and eventually disappear (at about 9–11 mm from the anterior extremity, according to Tubangui), leaving long, simple spines which gradually

become narrower until they are mere bristles. The oesophagus extends to a distance of 3.9–7 mm from the anterior end, and the cervical sacs, according to Tubangui, are about 2 mm long. The nerve-ring and the blunt cervical papillæ are situated at 0.75–1.38 mm from the anterior extremity.

The cuticle of the caudal end of the male is much inflated dorsally and laterally. Of the four pairs of stout lateral papillæ one is preanal and three are postanal. Between the first and second, and between the second and third, pairs from the posterior end there are two pairs of smaller subventral papillæ. Maplestone also describes "two crescentic prominences behind the cloaca". The tail has a papilla-like termination, as in other species. The spicules are stout and curved, and taper evenly from root to tip. "In cross section the spicules are seen to be circular, and to consist of a central core surrounded by a clear chitinous layer" (Maplestone). The left spicule measures 1.85–2.08 mm in length, the right 0.6–0.7 mm.

The tail of the female is blunt and, like that of the male, is surrounded by a large cuticular inflation. It measures 0.336 mm in length, according to Maplestone, and bears a pair of subterminal papillæ. The vulva is situated behind the middle of the body (at 10.4–19 mm from the posterior end, according to Maplestone). The eggs measure 0.052–0.067 × 0.031–0.037 mm, and have a thickened cap or wart-like process at each pole.

## 2 Genus *ECHINOCEPHALUS* Moln, 1858

Head-bulb armed with transverse rows of hooks, and showing no external evidence of the presence of the "balloons". No cuticular collar behind the head-bulb. Body unarmed. Caudal end of male with slight alæ. Eight pairs of caudal papillæ present, the most anterior pair separated by a long interval from the rest. Spicules slightly unequal. Vulva near the posterior end of the body. Uterine branches two. Adult worms in the intestine (usually in the spiral valve region) of Elasmobranch fishes.

Genotype — *Echinocephalus uncinatus* Moln, 1858

### Key to Species

- |   |                               |
|---|-------------------------------|
| Head bulb with not more than six rows of hooks                    | <i>uncinatus</i> , p 192      |
| Head-bulb with more than six rows of hooks                        | 1                             |
| 1. Dorsal and ventral lobes of lips each with eight or more teeth | <i>multidentatus</i> , p 197. |
| Dorsal and ventral lobes of lips each with two teeth              | 2                             |
| 2 Head-bulb with 15–18 rows of hooks                              | <i>southwelli</i> , p 195     |
| Head-bulb with 30–40 rows of hooks                                | <i>spinosissimus</i> , p 193  |

1 *Echinocephalus uncinatus* Molin, 1858, *sensu* Baylis and Lane, 1920 (Fig 105)

Synonyms —*Cheiracanthus uncinatus* v Linstow, in Shipley and Hornell, 1904, *Cheiracanthus (Echinocephalus) uncinatus* v Linstow, 1905, *Echinocephalus gracilis* Stossich, in Shipley and Hornell, 1906, ? *Echinocephalus aetobati* MacCallum, 1921

*Hosts* —Molin's original description of this form appears to have been based in part on specimens of *E spinosissimus* (*vide infra*) It was originally recorded from *Trygon bruceo* in the Adriatic, and has been found also in *Trygon pastinaca* and in *Myliobatis newhofi* off Ceylon, where immature forms were also recorded by Shipley and Hornell (1904) in the triggerfishes *Balistes mitis* and *B stellatus* The single immature

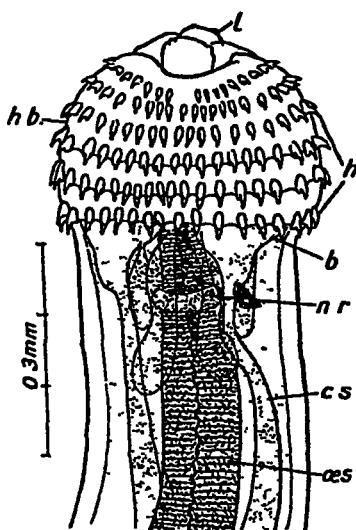


Fig 105—*Echinocephalus uncinatus* Anterior end of larval specimen, lateral view *b*, ballonet, *cs*, cervical sac, *h*, hooks, *hb*, head-bulb, *l*, lip, *nr*, nerve-ring, *oes*, oesophagus (After Baylis and Lane, in Proc Zool Soc)

form recorded by MacCallum (1921), under the name of *E aetobati*, from *Aetobatis narinari* off Java was also probably referable to *E uncinatus* Larvæ have been recorded in the pearl-oyster (*Margaritifera margaritifera*) by Shipley and Hornell, and in *Pinna* sp by Baylis and Lane (1920), off Ceylon. In the pearl-oyster the larvæ are occasionally found "entombed in the nacreous lining of the shell," their shape being wonderfully preserved

Unfortunately no adequate description of the adult worm is available Molin (1858; 1861, *a*) gives only a very brief diagnosis, consisting mainly of generic characters. The male attributed by him to this species was, as shown by Baylis

and Lane (1920), probably *E spinosissimus*. The specimens described by Baylis and Lane and by MacCallum were immature, and no more recent description appears to exist.

The female, according to Molin, measures 7 mm in length and 0.7 mm in thickness, and no other measurements are given by him. An immature specimen described by Baylis and Lane from *Myliobatis nieuhofi* measured 14 mm in length and 0.4 mm in thickness. The head-bulb, in this specimen, was 0.3 mm long and 0.4 mm wide. It bears six rows of hooks, according to all the describers. Each row, according to Baylis and Lane, contains between 40 and 50 hooks. These measure up to 0.055 mm in length, their size increasing from the anterior to the posterior row. According to MacCallum "the mouth [of *E aetobati*] apparently is studded with spines. The anterior semi-circular lip has spines on its inner surface, and the lower triangular-shaped lip also has spines on it." The oesophagus, according to MacCallum, is nearly half the length of the alimentary canal. In Baylis and Lane's specimen it extended to a distance of 3.5 mm from the anterior end, and the cervical sacs to 2 mm from the same point. The nerve-ring was situated at 0.4 mm, and the excretory pore at 0.62 mm, from the anterior extremity. The tail measures 0.3 mm or a little more in length.

## 2 *Echinocephalus spinosissimus* (v. Linstow, 1905) Baylis and Lane, 1920 (Figs 106 & 107.)

Synonyms — *Echinocephalus uncinatus* (♂) Molin 1858, *Cheirocanthus spinosissimus* v. Linstow, in Shapley and Hornell, 1905.

*Hosts* — v. Linstow's material was found in *Myliobatis aquila* from the Gulf of Manaar. Molin appears to have obtained this species, along with *E uncinatus*, from *Trygon brucco* in the Adriatic. Baylis and Lane (1920), who have redescribed the worm, record it from *Trygon walga* and *Urogymnus asperrimus* off Ceylon, while Taylor (1925, b) records it from *Trygon sephen* from the Ceylon pearl-banks.

v. Linstow's specimens, which were only 13.7 mm in length, appear to have been immature. Adult males measure 23–35.4 mm in length and 0.53–0.8 mm in maximum thickness, adult females about 31 mm and 0.86 mm respectively. The cuticular striations on the body are about  $2\mu$  apart. The head-bulb is subglobular and has a diameter of 0.48–0.81 mm. It is distinctly marked off from the "neck," and bears from 30 to 40 transverse rows of very small hooks. These measure 12.5–15  $\mu$  in length, and each row contains several hundreds of them. The rows are not always perfect rings, but may be incomplete and are sometimes branched. The lips are large, prominent and massive, and measure 0.24–0.41 mm in dorso-



at 1.25–1.35 mm from the posterior end. The vagina, together with the unpaired trunk of the uterus, runs forward for a distance of nearly 5 mm before giving off the uterine branches. No fully-formed eggs were seen by Baylis and Lane.

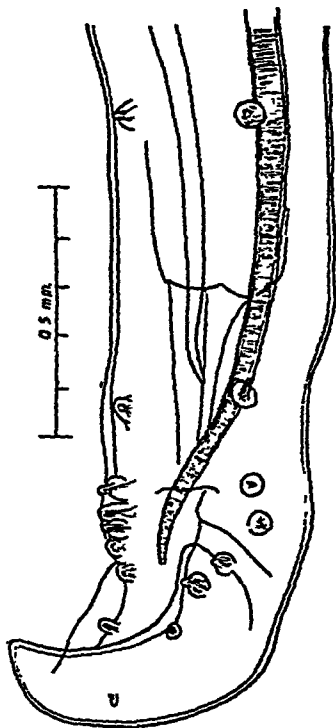


Fig 107 — *Echinocephalus spinosissimus*. Posterior end of male; ventral view (After Baylis and Lane, in Proc Zool Soc)

### 3 *Echinocephalus southwelli* Baylis and Lane, 1920 (Figs 108 & 109)

*Hosts* — This species was originally described from *Urogymnus asperrimus* off Ceylon, and has also been recorded by Taylor (1925, b) from a species of *Urogymnus* in the same region.

The male measures 21 mm in length and 0.5 mm in maximum thickness, the female 21.5 mm and 0.55 mm respectively. The cuticular striations on the body are 7–10  $\mu$  apart. The head-bulb measures 0.37 mm in length and 0.55 mm in width, and bears 15–18 rows of hooks, which have a maximum length of 0.035 mm. Each row contains probably about 150–200 hooks. The lips are somewhat depressed. Their dorsal and ventral lobes bear two teeth each. The oesophagus extends to a distance of 2.4–2.8 mm from the anterior end, and the cervical sacs to 2.25–2.55 mm. The nerve-ring is

situated at 0.42–0.55 mm, the cervical papillæ at 0.62–0.65 mm., and the excretory pore at 0.7–0.75 mm from the anterior extremity

The tail of the male is 0.3 mm long. Of the eight pairs of caudal papillæ three are preanal, one adanal and four postanal. The third and fourth pairs from the posterior end are rather nearer to the mid-ventral line, and the second and fourth are smaller than the rest. The most anterior pair of preanal papillæ is separated by a long interval from the next. The

Fig 108

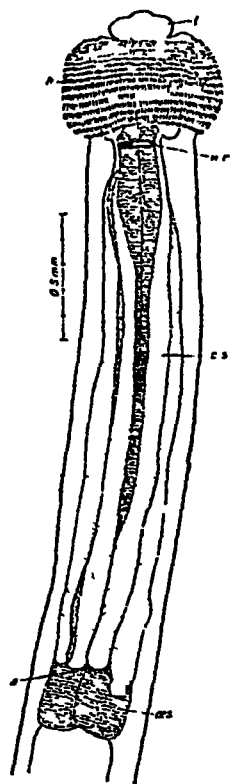


Fig 109

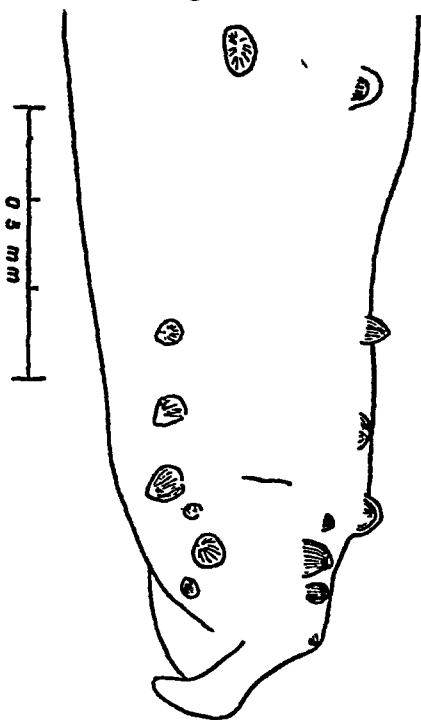


Fig 108—*Echinocephalus southwelli*. Anterior end, lateral view. *a*, button-like appendage of cervical sac, *cs*, cervical sac, *h*, hooks, *l*, lip, *nr*, nerve-ring, *es*, esophagus. (After Baylis and Lane, in Proc. Zool. Soc.)

Fig 109—*Echinocephalus southwelli*. Posterior end of male, ventral view. (After Baylis and Lane, in Proc. Zool. Soc.)

spicules are relatively slender and measure 2 mm in length. A little before the tip each spicule is narrowed, and then somewhat expanded, before terminating in a conical point.

The tail of the female is 0.23 mm long, and bears a pair of papillæ at 0.11 mm from its blunt tip. The vulva is situated at 0.55 mm from the posterior extremity. The vagina leads

into a very wide, sac-like uterine trunk, which gives off the two branches anteriorly. The eggs measure up to  $0.052 \times 0.03$  mm.

4 *Echinocephalus multidentatus* Baylis and Lane, 1920  
(Fig 110)

*Host* — *Urogymnus asperrimus*, off Ceylon

The male measures 14.7–15.3 mm in length and 0.55 mm in maximum thickness, the female 16.15–16.55 mm and 0.6 mm, respectively. The cuticular striations on the body are  $5\mu$  apart. The head-bulb is very conspicuous, being considerably wider than the body. Its length is 0.47–0.55 mm and its width 0.85–0.86 mm. It bears 11–13 rows of relatively large hooks, measuring 0.05–0.06 mm in length. Each row contains probably about 100 hooks. The inner surface of each dorsal and ventral lobe of the lips bears 8–11 longitudinal tooth-like ridges. The oesophagus extends to a distance of 1.9–2.3 mm.

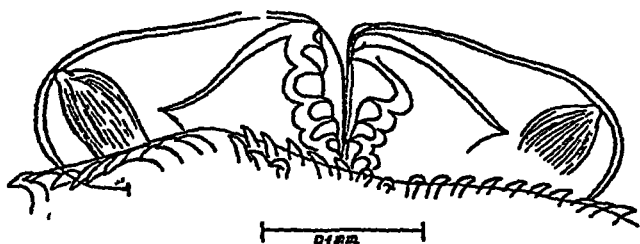


Fig 110 — *Echinocephalus multidentatus*. Anterior extremity, dorsal view (After Baylis and Lane, in Proc Zool Soc.)

from the anterior end, and the cervical sacs to almost the same level. The nerve-ring is situated at 0.65 mm, the cervical papillae and excretory pore at 0.75–0.9 mm, from the anterior extremity.

The tail of the male is 0.3 mm long. Of the eight pairs of caudal papillae three are preanal and five postanal. The two anterior pairs, which are widely separated, and the middle pair of postanal papillae, are conspicuously larger than the rest. The two most anterior pairs of postanal papillae lie at the same transverse level, one being more laterally situated than the other. The peduncles of most of the papillae have swollen bases. The spicules are rather slender. The left spicule measures 1.49 mm in length, the right 1.4 mm. Their tips are smooth and knob-like.

The tail of the female is 0.29–0.31 mm. long. It is bluntly conical, and carries a pair of papillae at 0.11 mm from the tip. The unpaired trunk of the uterus forms a voluminous sac. The eggs measure up to  $0.05 \times 0.03$  mm.

3 Genus **TANQUA** Blanchard, 1904

Synonyms — *Ctenocephalus* v. Linstow, 1904, *nec* Kolenati, 1857, *Tetradenos* v. Linstow, 1904, *Anomala* Travassos, 1920, *nec* Block, 1799

Head-bulb without spines, but with prominent transverse striations, and showing externally two or four swellings which contain the "ballonets". A cuticular collar present behind the head-bulb. Body unarmed. Caudal end of male with well-developed alæ. Eight pairs of caudal papillæ present, some of which have large swellings on their pulps. Spicules equal. Vulva in the posterior half of the body. Uterine branches either two (opposed) or four (three anterior and one posterior). Adult worms in the stomach of monitor lizards (*Varanus*) and snakes.

Genotype — *Tanqua tiara* (v. Linstow, 1879).

*Key to Species*

Head-bulb with four swellings, uterus with four branches	<i>tiara</i> , p. 198
Head-bulb with two swellings, uterus with two branches	<i>anomala</i> , p. 201

1. **Tanqua tiara** (v. Linstow, 1879) Blanchard, 1904 (Figs. 111–113)

Synonyms — *Ascaris tiara* v. Linstow, 1879, *Ctenocephalus tiara* v. Linstow, 1904, *Tetradenos tiara* v. Linstow, 1904

*Hosts* — This species, originally described from *Varanus ornatus* [probably *V. albigularis*] from Natal, occurs very commonly in a number of other species of monitors in Africa, Asia and Australasia. In India and Ceylon it has been recorded from *Varanus salvator*, *V. flavescens*, *V. nebulosus* and *V. monitor* [= *V. bengalensis*]. It is usually firmly attached by the head to the wall of the stomach.

The following description is taken mainly from Baylis and Lane (1920), with whose account that of Monnig (1924) closely agrees. The male measures 20–39 mm in length and 0.55–1.1 mm in maximum thickness, the female 20–44 mm and 0.9–1.4 mm respectively. The cuticular striations on the body are 4–5  $\mu$  apart. The head-bulb has a transverse diameter of 0.33–0.52 mm, and is divided (in mature specimens) by longitudinal grooves into four submedian swellings. In immature specimens it shows only two swellings, situated dorsally and ventrally. The transverse striations on the head-bulb are about 10–17  $\mu$  apart, and are interrupted by the longitudinal grooves. The lips are large and thick, and are somewhat flattened in front. On its inner surface each lip is produced into five tooth-like

longitudinal ridges, which interlock with those of the other lip. In dorso-ventral view there is seen on the edge of each "tooth" a little projection which appears to be the expression of a transverse ridge. There is a well-marked cuticular collar behind the head-bulb which, when the head-bulb is buried in the host's mucous membrane and drawn back

Fig 111

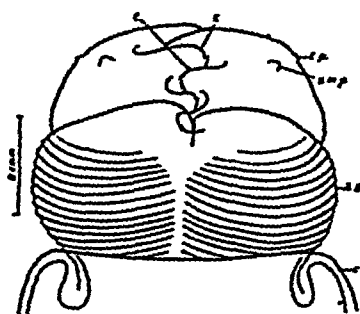


Fig 111—*Tanqua tiara* Anterior end; dorsal view. *c*, cuticular collar, *h b*, head-bulb, *l p*, lateral papilla, *s.m p.*, submedian papilla, *t, t*, teeth (After Baylis and Lane, in Proc Zool Soc)

Fig. 112

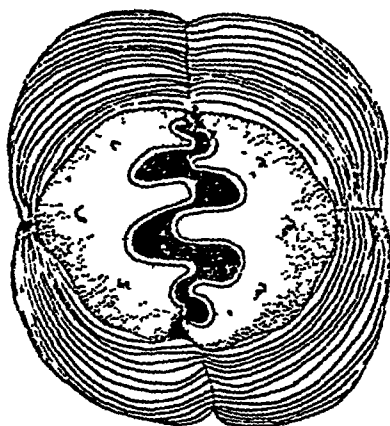


Fig 112—*Tanqua tiara* Anterior extremity, viewed *en face* (After Mönnig)

against it, forms a very effective holdfast. The œsophagus occupies about one-fifth of the total length, extending to a distance of 4.5–9.5 mm from the anterior extremity. The cervical sacs extend to about 1–1.9 mm from the same point, being roughly a quarter of the length of the œsophagus. The nerve-ring is situated at 0.6–0.93 mm, the excretory pore

at 0.84–1.2 mm, and the ceryical papillæ at 0.9–1.35 mm. from the anterior end.

The tail of the male is 0.5–0.7 mm. long. Of the eight pairs of caudal papillæ three are preanal, one adanal and four postanal. The adanal pair is the largest. The first, fourth and sixth pairs from the posterior end are small, while the rest have large swellings on their pulps. The spicules measure 1.2–1.72 mm in length. They have a small, smooth, rounded knob at the tip.

The tail of the female is conical and measures 0.3–0.65 mm. in length. It bears a pair of papillæ at 0.1–0.175 mm. from

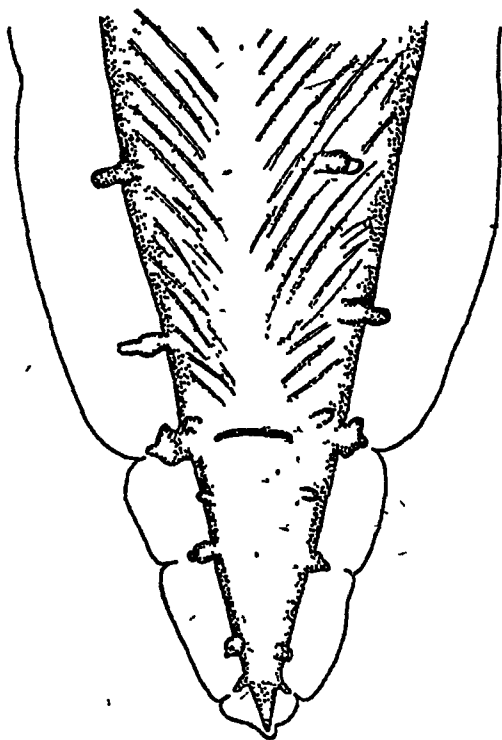


Fig. 113.—*Tanqua tara*. Posterior end of male, ventral view (After Mönnig.)

the tip. The vulva is situated within the posterior quarter of the body, at a distance of 4.8–7.8 mm. from the posterior end. The vagina has a short terminal ovejector, and runs forward from the vulva. The uterus has four branches, three of which at first run anteriorly and one posteriorly. There is, however, considerable variation in their mode of origin. They may originate by branching from a narrow stem continuous with the vagina, or simultaneously from an enlarged uterine sac of variable shape. The eggs measure 0.056–0.075 × 0.036–0.045 mm.

2 *Tanqua anomala* (v Linstow, 1904) Baylis, 1916 (Figs 114 & 115)

Synonym — *Heterakis anomala* v Linstow, 1904

*Hosts*:—This species has been found on several occasions in *Tropidonotus piscator* in India and Ceylon, and has also been recorded from *Homalopsis buccata* in Siam v Linstow's original description has been amplified by Baylis and Lane (1920)

The adult worms show considerable variation in size, males measuring 26–50 mm in length and 0.8–2 mm in maximum thickness, females 30.1–56 mm and 0.95–2 mm respectively. The anterior portion of the body tapers considerably, and the head-bulb is relatively small, having a transverse diameter of 0.23–0.42 mm. It is divided externally into two swellings

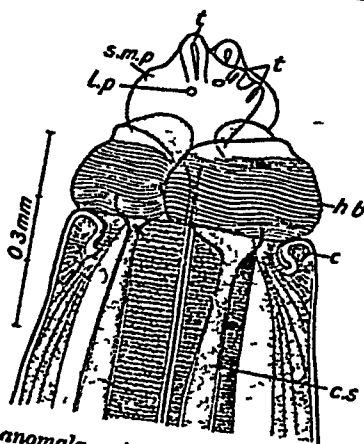


Fig 114—*Tanqua anomala* Anterior end, lateral view c, cuticular collar; c.s., cervical sac, hb, head-bulb, l.p., lateral papilla, s.m.p., submedian papilla, t, t, teeth (After Baylis and Lane, in Proc Zool Soc)

separated by lateral longitudinal grooves, and shows well-marked transverse striations  $7.5\text{--}16\ \mu$  apart. As in *T. tiara*, there is a well-developed cuticular collar behind the head-bulb. The lips are relatively large, prominent and somewhat conical in dorso-ventral view. The oesophagus extends back to a distance of 3–5.3 mm from the anterior extremity, and the cervical sacs to 0.65–1.2 mm. The nerve-ring is situated at 0.4–1 mm, the cervical papilla and excretory pore at about 0.73–1.3 mm, from the anterior end. The tail of the male is 0.45–0.9 mm long. The number and arrangement of the caudal papillae are as in *T. tiara*. The spicules measure 1.3–1.7 mm in length. The tail of the female is 0.4–1.3 mm long, and bears a pair of papillae at 0.25–0.38 mm from the tip. The vulva is

situated at about the posterior third of the body, at a distance of 9.8–18.7 mm from the posterior end. The vagina and the common trunk of the uterus are very short. There are two directly opposed uterine branches. The eggs measure up to  $0.065 \times 0.05$  mm.

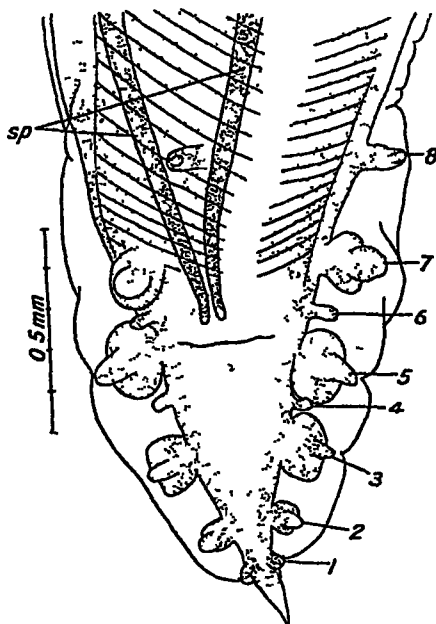


Fig. 115—*Tanqua anomala*. Posterior end of male, ventral view. *sp*, spicules, 1–8, papillæ of left side (After Baylis and Lane, in Proc Zool Soc.)

### Subfamily SPIROXYINÆ Baylis and Lane, 1920

Head-bulb, "ballonets" and cervical sacs absent. Lips wide, with narrowed base and trefoil-shaped pulp. The thickened internal cuticle of the median lobe of each lip projects anteriorly as a tooth.

#### 1 Genus **SPIROXYS** Schneider, 1866

Body unarmed. A cuticular collar may be present behind the bases of the lips. Caudal alæ of male inflated and continuous ventrally in front of the cloacal aperture, where they form a vesicular swelling. Between this swelling and the cloacal aperture there may be a sucker-like muscular depression. Eleven pairs of caudal papillæ present, of which four are preanal. Spicules subequal. Vulva in the posterior half of the body. Uterine branches two, opposed. Adult worms in the stomach of tortoises.

Genotype —*Spiroxys contorta* (Rudolph, 1819)

*Key to Species*

Each lip with six teeth in addition to the median tooth

*gangetica*, p 203

Each lip with a median tooth only

*annulata*, p 204

1, *Spiroxys gangetica* Baylis and Lane, 1920 (Figs. 116 & 117)

*Host*.—*Trionyx gangeticus*, Ganges delta

The male measures 39–43 mm in length and 0.75 mm.

Fig 116

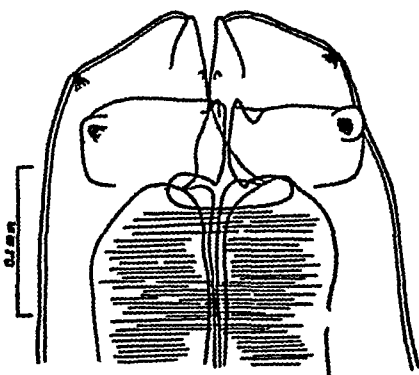


Fig 117

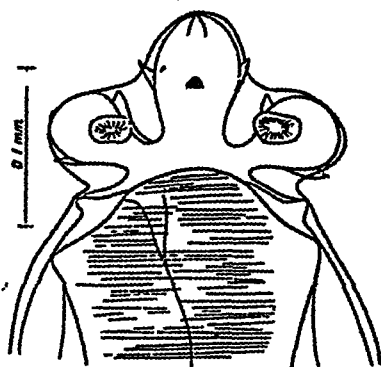


Fig 116—*Spiroxys gangetica* Anterior end, dorsal view  
(After Baylis and Lane, in Proc Zool Soc)

Fig 117—*Spiroxys gangetica* Anterior end, lateral view  
(After Baylis and Lane, in Proc Zool Soc)

in maximum thickness, the female 48–50.3 mm and 0.85–0.95 mm respectively. The cuticular striations are 12.5–17.5  $\mu$  apart. The anterior end of the body tapers more gradually than the posterior end, and is usually bent at an angle. The lips have a dorso-ventral diameter of 0.11–0.13 mm. Close to either edge and near its base each lobe of either lip bears

a cuticular tooth on its inner surface. Thus each lip has six teeth in addition to the median tooth. The inner surface of each dorsal and ventral lobe is flattened against that of the opposite lobe. A cuticular collar is present behind the bases of the lips. The œsophagus (measured from the anterior extremity) is 3.9–4.3 mm long. The nerve-ring is situated at 0.75–0.825 mm, the excretory pore at 0.9–1.15 mm, and the cervical papillæ at 1.2–1.5 mm, from the anterior end.

The tail of the male measures 0.35 mm in length. The caudal alæ are well developed, and inflated in such a way that the terminations of the lateral papillæ are deeply buried in them. Of these papillæ there are nine pairs, three preanal and six postanal. There are also two pairs of smaller subventral papillæ, one in front of and one behind the cloacal aperture. The pulps of these subventral papillæ are cup-shaped or forked at their ends. The left spicule is 2.25 mm long, the right 2.1 mm. The granular ornamentations on their surfaces tend to be arranged in transverse rows, and each spicule has a blunt tip surmounted by a hyaline cap.

The tail of the female is 0.65 mm long, and is conical and slightly curved ventrally. It has a terminal spike forming a small hook, and bears a pair of papillæ at 0.32 mm from the tip. The vulva is situated at 20–27 mm from the posterior end. The eggs measure up to  $0.06 \times 0.04$  mm.

## 2 *Spiroxys annulata* Baylis and Daubney, 1922 (Figs 118 & 119)

Synonym —? *Spiroxys torquata* Karve, 1928 \*

*Hosts* —This species was described from the stomach of *Chitra indica* from Ludhiana, Punjab. The form described by Karve under the name of *S. torquata* is recorded from *Lissemys punctata granosa* [= *Emyda granosa intermedia*] at Nagpur, Central Provinces.

The male measures 20–25.4 mm in length and 0.5–0.6 mm in maximum thickness, the female 30–34 mm and 0.8–0.85 mm respectively. The cuticular striations are relatively coarse (up to  $25 \mu$  apart) and have prominent posterior edges, giving the outline of the body a serrated appearance in optical section. The lips, in dorso-ventral view, are more wedge-shaped an-

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\* *S. torquata* differs only in very small points from *S. annulata*. Karve (1928) distinguishes it on the ground that the median tooth-like projections of the lips are more prominent, but this may be a variable feature, and can hardly be regarded as a satisfactory specific character. There are slight differences in the measurements, the most important of which are in the length of the tail of the female (0.52–0.54 mm in *S. torquata*) and the position of the vulva (6.7 mm from the posterior end in a specimen of *S. torquata* measuring 33 mm in length). The eggs of *S. torquata* are said to measure  $0.09 \times 0.067$  mm.

teriorly than in *S. gangetica*. They are without the six pointed teeth present in that species. Their dorso-ventral diameter is 0.16 mm. There is a well-marked cuticular collar

Fig 118

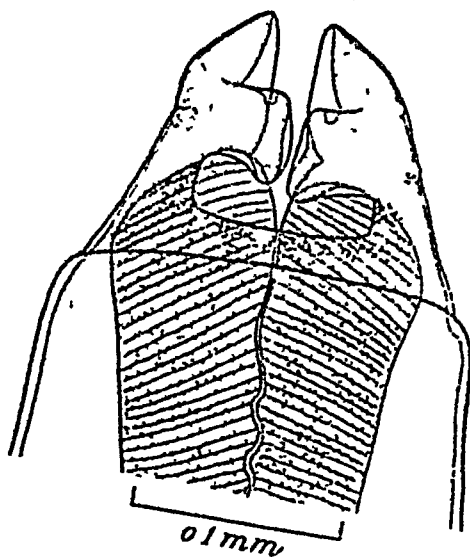


Fig 119

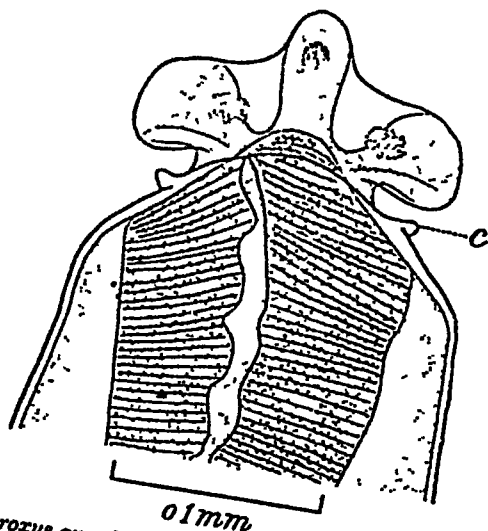


Fig 118—*Spiroxys annulata* (After Baylis and Daubney)  
Anterior end of female, dorsal view  
Fig 119—*Spiroxys annulata* (After Baylis and Daubney)  
c, cuticular collar  
Anterior end of female, lateral view

behind their bases The oesophagus (measured from the anterior extremity) is 2·8–3·5 mm long Except for a short, purely muscular portion at the anterior end, its walls contain many pocket-like glands arranged in several linear series The nerve-ring is situated at 0·62–0·65 mm, the excretory pore at 0·8 mm, and the cervical papillæ at a little more than 1 mm., from the anterior end These papillæ resemble small, backwardly-directed spines

The tail of the male is about 0·2 mm long The inflation of the caudal alæ is very pronounced Behind their anterior junction there is a sucker-like muscular depression The number and arrangement of the caudal papillæ are as in *S. gangetica*, but the small subventral pairs are sessile The spicules are nearly equal in length (1·6–2·3 mm), slender, cylindrical and finely pointed

The tail of the female measures about 0·2 mm in length and is sharply conical, with its tip bent ventrally. The caudal papillæ are situated at 0·17 mm from the tip. The vulva is situated slightly behind the middle of the body, at 13·8–15·5 mm from the posterior end The muscular vagina is very narrow and runs forward from the vulva The eggs measure about  $0·075 \times 0·06$  mm.

## 5. Family CAMALLANIDÆ Railliet and Henry, 1915.

Lips absent Mouth a dorso-ventral slit A buccal capsule present, whose wall is either entire or separated into two lateral scallop-shell-like valves Oesophagus consists of two portions of almost equal length, a club-shaped, muscular anterior portion and a glandular posterior portion Caudal end of male with alæ, into which project a number of pedunculate papillæ Spicules unequal and dissimilar, the right longer than the left Vulva prominent, in the middle region of the body, the vagina running posteriorly from it Uterine branches opposed, the posterior branch ending blindly, without an ovary Females viviparous

### Key to Genera

- |   |                      |
|---|----------------------|
| Wall of buccal capsule entire   | PROCAMALLANUS, p 218 |
| Wall of buccal capsule divided into lateral valves  | 1                    |
| 1 A pair of trident-shaped structures present dorsally and ventrally to the buccal valves | CAMALLANUS, p 207    |
| The trident-shaped structures replaced by simple rods                                     | CAMALLANIDES, p 214  |

1. Genus **CAMALLANUS** Rauber and Henry, 1915

Buccal capsule composed of two separate lateral valves with rib-like longitudinal thickening internally. A chitinous ring is present at the junction of the valves with the oesophagus, and opposite to the dorsal and ventral edges of the valves a pair of trident-shaped chitinous structures with lateroventrally-directed prongs. Male without an ovicell, piece. Lapp of vulva prominent but not forming a tubular appendage. Adult worms in the alimentary canal of reptiles, amphibians and fishes.

Genotype — *Camallanus lactator* (Zoox, in Müller, 1777)

*Key to Species*

- |   |                           |
|---|---------------------------|
| Longer species of male reaches 1 mm long; parasite of insects | <i>lactator</i> , p. 207  |
| Longer species of male less than 0.5 mm long                  | 1.                        |
| 1. Male 5-7 mm, female 14-23 mm long; parasite of fish        | <i>lactator</i> , p. 210  |
| Male 7-12 mm, female up to 55 mm long; parasite of fish       | <i>ovicellus</i> , p. 212 |

1 **Camallanus kachuzovi** Baylis and Daubney, 1922 (Figs 120-122.)

Host — *Kachuzovi*, Pirogore, Punjab

The male measures 10.9-14.5 mm in length and 0.3-0.37 mm

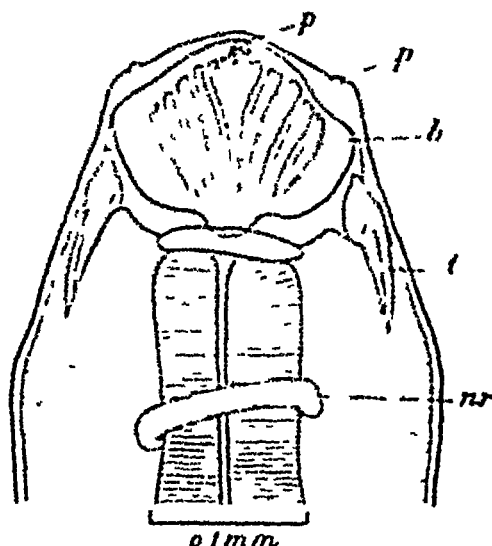


Fig 120 — *Camallanus kachuzovi*. Anterior end of female, lateral view. *b*, buccal valve, *nr*, nerve-ring; *p*, *p*, papillae; *t*, "trident" (After Baylis and Daubney)

in maximum thickness, the female 20·8–22 mm and 0·45–0·5 mm respectively. The cuticular striations are not more than  $5\mu$  apart. The dorso-ventral diameter of the head, at its anterior angles, is about 0·13–0·15 mm in the male and 0·17 mm in the female. The buccal valves are slightly

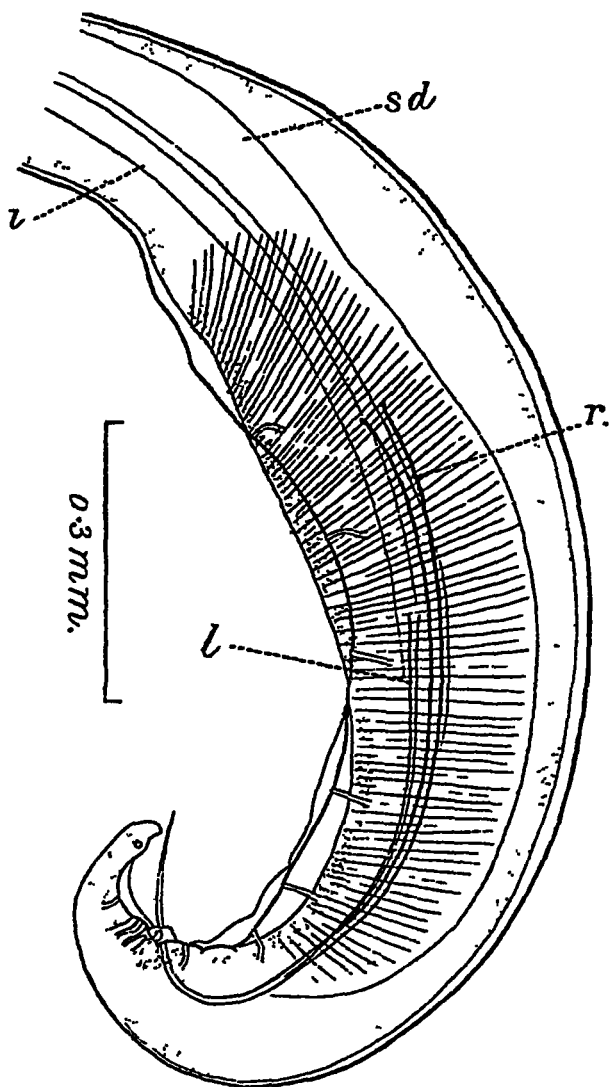


Fig 121—*Camallanus lachugæ* Posterior end of male, lateral view *i*, intestine, *l*, left spicule, *r*, right spicule, *sd*, sperm-duct (After Baylis and Daubney)

broader than long. Their length (excluding the posterior ring) is 0·11–0·13 mm, and their width about 0·14–0·16 mm. There are either eight or ten longitudinal ridges on each valve,

the latter number occurring only in large specimens. The posterior ring of the buccal apparatus has a diameter of 0.1 mm. The "tridents" are well developed, the middle prong measuring 0.05-0.1 mm. in length. The total length of the oesophagus, measured from the extremity of the head, is 1.18-1.55 mm. Its anterior portion, measured from the same point, is 0.51-0.66 mm. long. The nerve ring is situated at 0.2-0.23 mm., and the minute, bristle-like cervical papillae at 0.5-0.55 mm., from the anterior end. The excretory pore is at about the same level as the papillae. The intestine is considerably narrower than the oesophagus.

The body of the mite is somewhat thicker in the region of the caudal alae than in the portion immediately preceding it. The ventral region between the alae is probably capable of being

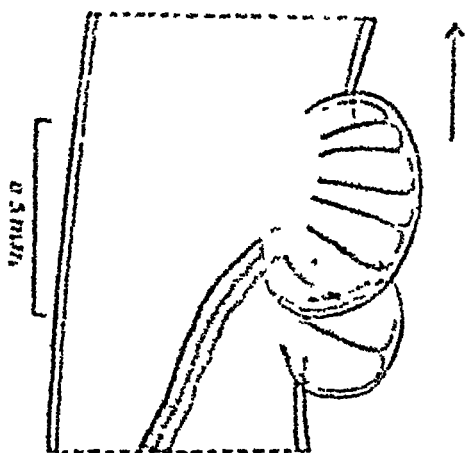


FIG. 122.—*Camaliang longicauda*. Vulvar region of female, lateral view (Intestine and uterus omitted. The arrow points towards the anterior end.) (After Baylis and Daubney.)

depressed by the caudal muscles so as to form a sucker-like organ. There are seven pairs of pedunculate preanal papillae, two pairs of adanal and six pairs of postanal papillae. The two posterior pairs are isolated while the third, fourth and fifth pairs form a group, all being close together. All these are lateral, while the sixth pair is more ventrally situated, just behind the cloacal aperture. The right spicule is relatively stout and measures about 0.97 mm. in length. Its tip appears to be simple and finely pointed. The left spicule is very slender and measures about 0.43 mm. in length.

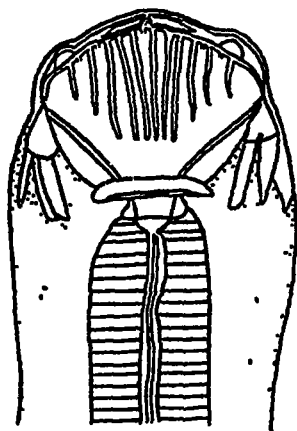
The tail of the female is finger shaped, rather blunt and slightly bifid at the tip. It is about 0.3 mm. long, and bears a pair of papillae at 0.17 mm. from the tip. These papillae

are situated in slight depressions in the cuticle. The vulva is situated in front of the middle of the body, at a distance of 9.1–10.4 mm. from the anterior end. It has exceedingly prominent lips, the anterior lip being larger than the posterior and overlapping it. Each of the lips consists of a cuticular swelling with granular contents, and has the appearance of being divided internally into several compartments by cuticular partitions. The vagina is very narrow and runs back almost straight for about 2 mm. It gradually widens into the short common trunk of the uterus, which continues to run posteriorly.

## 2 *Camallanus baylisi* Karve, 1930 \* (Figs 123 & 124)

*Host* — *Rana tigrina*, Nagpur, Central Provinces

The male measures 8–9.5 mm. in length and about 0.26–0.27 mm. in maximum thickness, the female 14–20 mm. and about 0.4 mm. respectively. The cuticle is finely striated.



0.1 mm.

Fig 123 — *Camallanus baylisi* Anterior end of female, lateral view (After Karve)

The dorso-ventral diameter of the head, at its anterior angles, is about 0.083–0.098 mm. in the male and 0.12–0.17 mm. in the female. The buccal valves are broader than long, and broader in front than behind. Their length (excluding the posterior ring) is about 0.07–0.09 mm. in the male and 0.13–

\* It appears very probable that this species is synonymous with '*Cucullanus*' *nigrescens* v. Linstow, 1906, a form recorded from *Rana hexadactyla* (locality not mentioned). From v. Linstow's (1906, a) description, however, the identity of the species cannot be established with certainty.

0.15 mm in the female, their width about 0.1–0.12 mm and 0.14–0.19 mm in the two sexes respectively. "The number of longitudinal ridges on each valve varies between nine and eleven, the latter number being almost always found in fully developed specimens. Between two ridges is situated a small chitimized tooth-like projection." The posterior ring of the buccal apparatus has a diameter of about 0.066–0.07 mm in the male and of 0.08 mm in the female. The "tridents" are well developed, but show considerable variation in size and shape. The middle prong varies in length from 0.027 to 0.04 mm. The anterior portion of the oesophagus measures about 0.48–0.52 mm in length in the male, and 0.6–0.65 mm in the female. The posterior portion is about 0.43–0.54 mm long in both sexes. The nerve-ring is situated at about

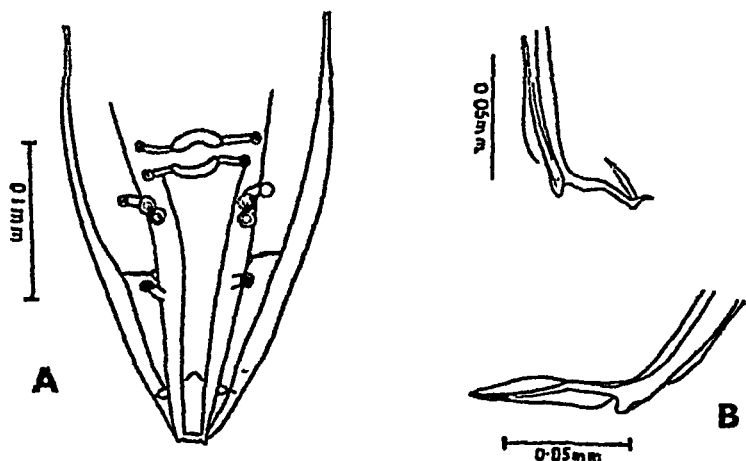


Fig 124—*Camallanus baylisi*. A, posterior end of male, ventral view, B, variations in the appearance of the tip of the right spicule (After Karve)

0.14–0.25 mm, the small cervical papillae at about 0.19 mm., and the excretory pore at about 0.31–0.37 mm, from the anterior extremity. The intestine is somewhat narrower than the oesophagus.

The tail of the male is 0.16–0.18 mm long, and has a bifid tip. The caudal alae extend for a length of about 0.7–0.8 mm, and have a maximum width of about 0.29 mm. There are seven pairs of preanal, two pairs of adanal and six pairs of postanal papillae. Of the latter the most posterior on each side is isolated, the third from the posterior end has a slender termination and a thickened base, and the fourth, fifth and sixth all lie close together. The right spicule is relatively stout and measures about 0.47 mm in length. It is alate

distally and has a lateral barb or prong near the tip. The left spicule is slender and measures about 0.15–0.23 mm in length.

The tail of the female is about 0.13 mm long, and is finger-shaped, with three small spines at the tip. These spines are larger in immature specimens. The vulva is situated in front of the middle of the body, at a distance of 5.35–6.9 mm from the anterior end. The narrow, muscular vagina gives origin to the uterine branches at a distance of about 1.5 mm from the vulva. The posterior branch terminates at about 2.8 mm. from the posterior end.

### 3 *Camallanus sweeti* Moorthy, 1937 (Figs 125 & 126)

*Host* —*Ophiocephalus gachua*, Chitaldrug district, Mysore State. Nearly 100 per cent of the fish of this species taken from step-wells were found to be infested.

The male measures 3–3.9 mm in length and up to 0.13 mm in thickness, the female 3.2–5.5 mm and up to 0.15 mm

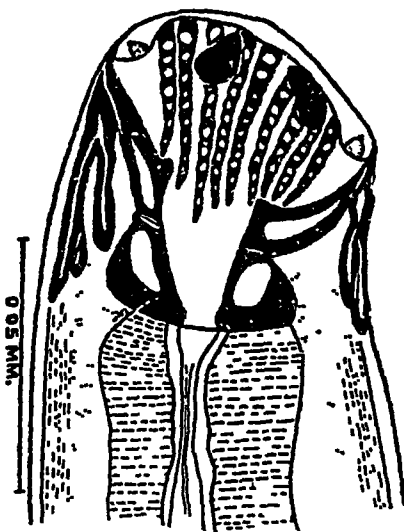


Fig 125 —*Camallanus sweeti*. Anterior end of female, lateral view (After Moorthy)

respectively. The cuticular striations are not more than  $4\mu$  apart. The buccal valves (including the basal ring) measure 0.06–0.07 mm in length. Each valve carries nine internal longitudinal ridges, which have a beaded appearance, and two quadrilateral external thickenings. The "tridents" have a middle prong measuring about 0.046 mm in length, and outer prongs measuring about 0.025 mm. The anterior portion of the oesophagus measures 0.31–0.42 mm in length,

the posterior portion 0.38–0.52 mm. The nerve-ring is situated at the anterior third of the former, and the excretory pore (in the female) at about 0.16 mm from the anterior extremity.

The tail of the male is 0.05–0.063 mm long. In immature specimens there are three subequal terminal spines, as in the female. In mature males the median spine is relatively very small, the two ventro-lateral spines large. There are 13–15 pairs of caudal papillæ, of which 4–6 are preanal, one adanal and eight postanal. "Numbering from the posterior extremity, pairs 1 and 2, lateral and in a group, pair 3, ventro-lateral and isolated; pairs 4 and 5, ventro-lateral

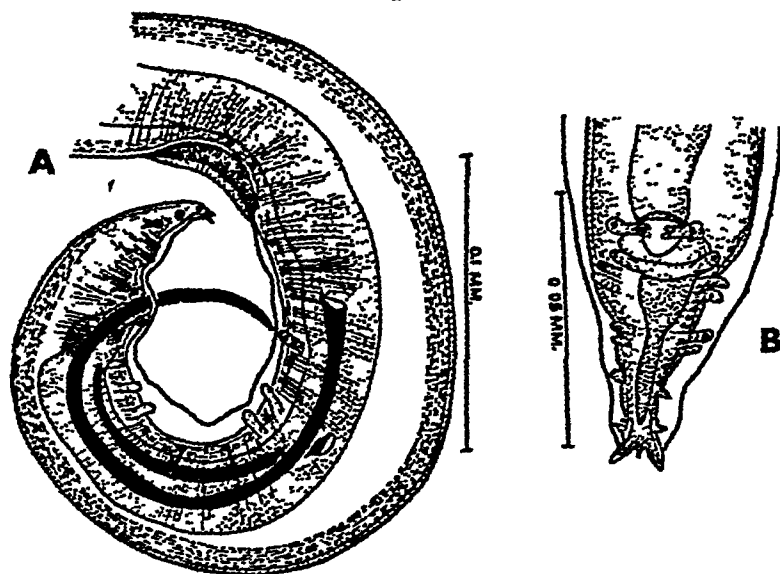


Fig 126—*Camallanus sweetsi*. Posterior end of male  
A, lateral view; B, ventral view (After Moorthy)

and in a group, pairs 6 and 7, ventro-lateral and in a group; pairs 8 and 9, circumanal and isolated, preanal papillæ variable, 4–6 pairs, subventral to ventro-lateral, in majority of specimens 5 pairs present." A sucker-like organ is present at a distance of about 0.32 mm from the posterior extremity. The right spicule measures 0.21–0.3 mm in length. The left spicule is much more slender and measures 0.1–0.18 mm.

The tail of the female is 0.05–0.07 mm long, and bears three spines at its tip. The vulva is situated at 2–3 mm from the anterior end, and has prominent lips. In gravid females the posterior lip is pushed to one side by the overhanging anterior lip, forming a lateral projection. The vagina is narrow and runs back for a distance of about 0.3 mm.

According to Moorthy's (1937, *b*, 1938, *b*) observations the first intermediate hosts of this species are *Cyclops leuckarti* and *C. hyalinus*, the second hosts small fishes (*Barbus puckelli*, *B. ticto*, *Lepidocephalichthys thermalis*) which occur in the same wells and are preyed upon by the final host. The larvæ were also found in *Gambusia* sp., introduced from Italy for the control of *Cyclops*. In the second host the larvæ become encysted in the wall of the intestine.

### **Camallanus sp.**

Chatterji (1936) records a single immature female specimen of a species of *Camallanus* from the intestine of a freshwater tortoise (*Morenia-ocellata*) at Rangoon, Burma. The worm measured 112 mm in length. The buccal valves were broader than long, and each carried ten longitudinal ridges. The vulva was situated in front of the middle of the body, and had a prominent anterior lip.

### **Camallanus sp.**

Moorthy (1938, *b*) describes a single third-stage larva of an undetermined species of *Camallanus* from *Cyclops leuckarti* in Mysore. He also describes encysted larvæ of an undetermined Camallanid from the body-cavities of *Barbus puckelli*, *Lepidocephalichthys thermalis* and *Ophiocephalus gachua*.

## **2 Genus CAMALLANIDES Baylis and Daubney, 1922**

Buccal capsule composed of two separate lateral valves similar to those of *Camallanus*, but each having two large chitinous thickenings externally "Tridents" reduced to simple rods. An accessory piece present in the male. Vulva carried on a tubular appendage. Adult worms in the alimentary canal of snakes and frogs.

Genotype — *Camallanides prashadi* Baylis and Daubney, 1922.

### **1 Camallanides prashadi Baylis and Daubney, 1922 (Figs. 127-130)**

*Hosts* — King cobra, (*Naja hannah* [= *N. bungarus*])\*, banded krait (*Bungarus fasciatus*) and rat-snake (*Ptyas [Zamenis] mucosus*), Zoological Gardens, Calcutta (Baylis and Daubney, 1922, 1923, *b*). A single male specimen †

\* See Baylis 1929, Ann. & Mag. Nat. Hist. (10) iv, p. 50.

† This specimen was somewhat larger than the types, measuring 76 mm in length.

is recorded by Karve (1930) from the small intestine of *Rana tigrina* at Nagpur, Central Provinces

The male measures 5.8–6.6 mm. in length and 0.21–0.25 mm.

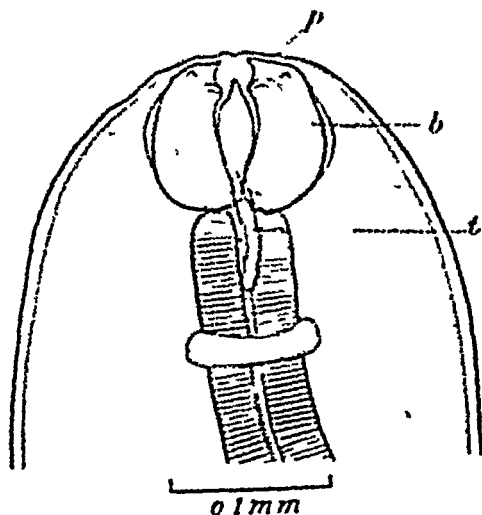


Fig 127—*Camallanides prashadi*. Anterior end of female, dorsal view. *b*, buccal valve, *p. p.*, papillae, *t*, "trident" (After Baylis and Daubney)

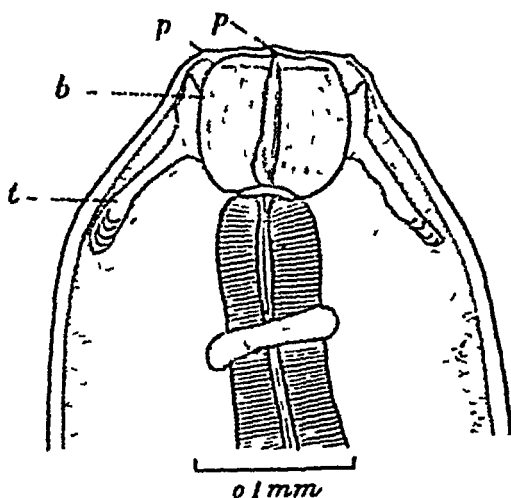


Fig 128—*Camallanides prashadi*. Anterior end of female, lateral view. *b*, buccal valve, *p. p.*, papillae; *t*, "trident" (After Baylis and Daubney)

in maximum thickness, the female 14.2–17.7 mm. and 0.4–0.47 mm respectively. The cuticular striations are very

fine and indistinct, at intervals of about  $3-4\mu$ . The diameter of the head, measured dorso-ventrally at the anterior angles, is  $0.08-0.09$  mm in the male and  $0.12-0.13$  mm in the female. The buccal valves present the appearance of four separate brown chitinous masses. In reality each valve has two large external thickenings, separated by a longitudinal groove, and bears internally about 14 longitudinal ridges terminating anteriorly in tooth-like projections. The "tridents" are represented by simple chitinous rods of rather irregular shape and of a yellow colour. These are connected

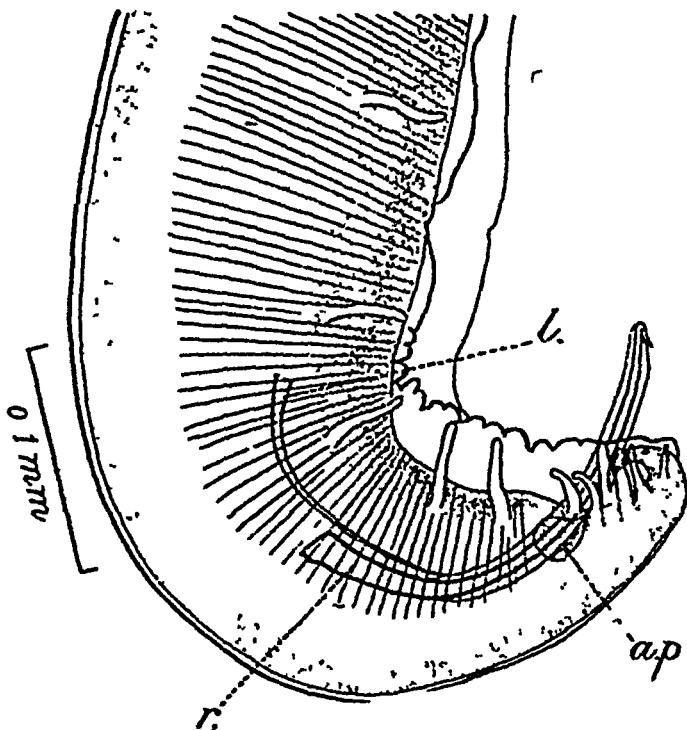


Fig 129.—*Camallanides prashadi*. Posterior end of male, lateral view. *ap*, accessory piece, *l*, left spicule, *r*, right spicule (After Baylis and Daubney)

at their bases with a dorsal and a ventral chitinous body lying opposite to the edges of the valves. The valves measure  $0.06$  mm in length in the male and  $0.09-0.1$  mm in the female. Their width is  $0.075$  mm in the male and  $0.1$  mm in the female. The length of the rods is about  $0.06$  mm in the male and  $0.07-0.1$  mm in the female. The posterior ring of the buccal apparatus has a diameter of  $0.033$  mm in the male and of  $0.045$  mm in the female. The anterior portion of the oesophagus measures (from the extremity of the head)  $0.38$  mm in length in the male and

0.47–0.5 mm in the female. The entire oesophagus (measured from the head-end) is 0.8 mm long in the male, and about 1 mm in the female. The nerve-ring is situated at 0.15 mm in the male, 0.19 mm in the female, from the anterior end, the excretory pore at 0.25 mm (male), 0.31 mm (female), and the minute, bristle-like cervical papillae at 0.28 mm (male), 0.35 mm (female).

The male has well-developed caudal alae. The tail is very short (a little over 0.06 mm), sharply pointed and usually curled ventrally, with its tip hidden by the alae. The caudal papillae are pedunculate and diminish in size posteriorly. There are seven pairs of preanal papillae, two pairs curving towards the ventral surface at the sides of the cloacal aperture, and five pairs of lateral postanal papillae. Of the latter the three anterior on each side are relatively large and close together. The right spicule is stout and is provided with alae for the greater part of its length. It is about 0.24 mm

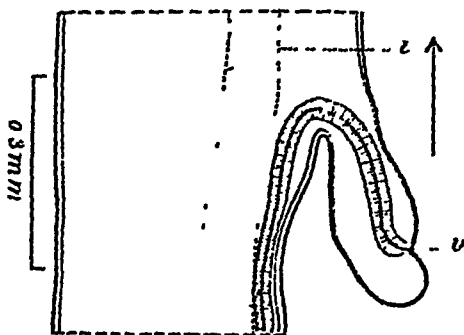


Fig 130—*Camallanides prashadi*: Vulvar region of female, lateral view. *i*, intestine, *v*, vulva (Uterus omitted). The arrow points towards the anterior end. (After Baylis and Daubney.)

long. Its tip is curled into a hook, but without a barb. The left spicule is without alae, slender and tapering, and measures about 0.14 mm in length. The accessory piece is somewhat triangular and measures about 0.025 mm in length.

The tail of the female is 0.4–0.6 mm long, and tapers gradually, with the exception of a slight thickening just before the conical tip. The lips of the vulva are modified into a tubular appendage, somewhat flattened dorso-ventrally and projecting freely from the body-wall in a posterior direction to a distance of 0.3–0.4 mm. This appendage originates at a point a little behind the anterior third of the body, at 5.9–6.1 mm from the anterior end. The vulvar aperture is situated on the ventral surface of the appendage near its

extremity. The narrow vagina runs from the opening to the base of the appendage, and then turns back just within the ventral body-wall, running straight back for about 2 mm before opening into the uterus. The posterior uterine branch is, as in *Camallanus*, without an ovary.

### 3 Genus **PROCAMALLANUS** Baylis, 1923

Buccal armature a continuous chitinous capsule, not separated into paired valves. Its wall may be smooth or provided internally with spiral thickenings. "Tridents" absent. Male without accessory piece. Vulva with prominent anterior lip. Adult worms in the alimentary canal of fishes.

Genotype —*Procamallanus læviconchus* (Wedl, 1862)

#### *Key to Species*

- |  |                           |
|--|---------------------------|
| Male 16-19 mm, female up to 33 mm long,<br>spicules of male 0.25 mm long | <i>mehrii</i> , p 218     |
| Male about 4 mm, female 5-7 mm long, spicules<br>of male 0.12 mm long    | <i>planoratus</i> , p 219 |

#### 1 *Procamallanus mehrii* Agarwal, 1930 (Fig 131)

*Host* —*Wallago attu*. The worms are said to have been found mainly in the posterior part of the body-cavity, but one specimen was in the gas-bladder.

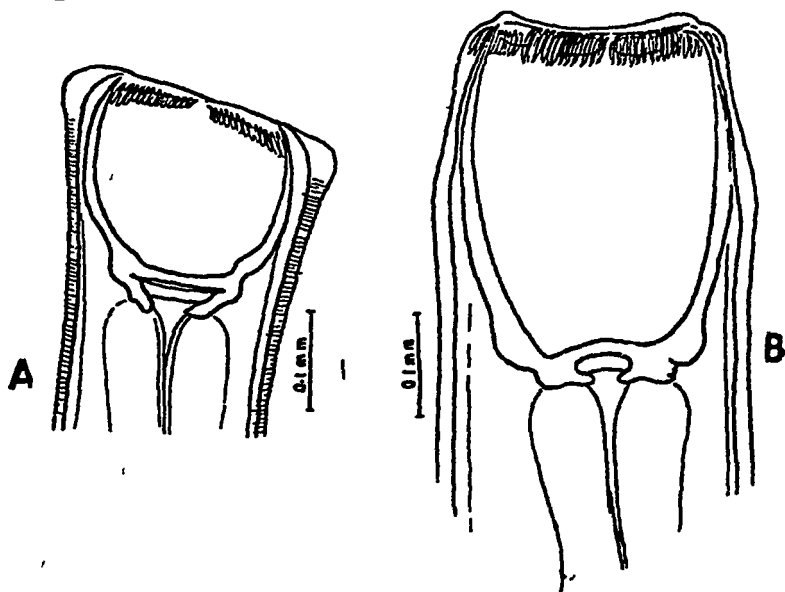


Fig 131 —*Procamallanus mehrii*. Anterior end. A, male, B, female (After Agarwal.)

The male measures 16-19 mm in length and about 0.32-0.36 mm in maximum thickness, the female 33 mm

and 0.425 mm respectively. The cuticular striations are  $36\mu$  apart. The buccal capsule measures 0.17 mm. in length, and the same in width, in the male. In the female it is 0.35 mm long and 0.2 mm wide. The shape of the capsule is quite different in the two sexes. In the male it is cup-shaped, in the female much more elongate and barrel-shaped. Its wall is apparently without spiral 'thickenings'. "At the anterior end of the buccal cavity there are present four chitinous plate-like structures, of which the two median ones are much larger. They are slightly separated from each other and are covered on the sides by the leaf crowns which are special outgrowths of the body-wall at the anterior end in the head region. The leaf crowns in the neighbourhood of middle plates are 9-10 in number in the male and 12 in the female, whereas those lying close to the outer plates are 6-7 in the male and 10 in the female. Their form also differs in the two sexes, in the male specimen they are more or less conical, while in the female they are elongated and more or less spindle-shaped" (Agarwal, 1930). The anterior portion of the oesophagus is 0.92-1.14 mm long in the male and 1.61 mm. in the female, the posterior portion 0.8-1.02 mm and 1.41 mm respectively. The nerve-ring is situated at about 0.27-0.32 mm in the male, and 0.53 mm in the female, from the anterior end, while the excretory pore is at about 0.48-0.5 mm and 0.96 mm respectively from the same point.

The tail of the male measures about 0.1 mm in length. The caudal alæ are 0.94-1.2 mm long. There are said to be eleven pairs of caudal papillæ, and an unpaired papilla near the tip of the tail, but the arrangement of the papillæ is not clearly described or figured. The spicules are equal (0.255 mm) in length.

The tail of the female is 0.23 mm long. The vulva is situated at a distance of 10 mm from the posterior end of the body. The cuticle is thickened in the vulvar region, forming a "crenated" swelling ventrally immediately in front of the vulva, and a larger swelling on the dorsal surface.

## 2 *Procamallanus planoratus* Kulkarni, 1935

*Host* —*Clarias magur* [= *C. batrachus*] (intestine), Nagpur, Central Provinces.

The male measures 3.85 mm in length and 0.061 mm. in maximum thickness, the female about 5-7.3 mm and 0.079 mm respectively. The cuticle is said to be unstriated. The buccal capsule measures 0.082 mm in length and 0.061 mm in width, and is without ridges or "leaf-crowns". The basal ring of the buccal apparatus is said to be represented by two chitinous masses, which are described as knob-like structures. The oesophagus (measured from the anterior extremity)

is 0.41 mm long. The nerve-ring is situated at 0.24 mm, and the excretory pore at 0.31 mm, from the anterior end.

The caudal end of the male is slightly curved ventrally and bluntly rounded at the tip. There are eight pairs of pedunculate papillæ, seven of which are preanal and one postanal. The spicules are equal (0.12 mm) in length.

The tail of the female is 0.11 mm long, and has a blunt tip. The vulva is situated at 1.4–3.38 mm from the posterior end of the body. Its anterior lip forms a prominent lobe.

## 6. Family CUCULLANIDÆ Cobbold, 1864.

Mouth a dorso-ventral slit bounded by large lateral lips. Oesophagus club-shaped and composed of two portions, but without a distinct glandular portion, and usually dilated anteriorly to form a large, muscular "false buccal cavity" without specially thickened lining. An intestinal cæcum sometimes present. Male with rudimentary caudal alæ, or none, but usually with a muscular preanal sucker-like organ. Spicules equal. An accessory piece usually present. Vulva behind the middle of the body, the vagina running anteriorly from it. Uterine branches opposed. Females oviparous.

### 1 Genus CUCULLANUS Muller, 1777.

Synonyms —*Cucullanus* Bloch, 1782, *Pleurorhynchus* Nau, 1787; *Pleurorhynchus* Rudolphi, 1801, *Cucullus* Zeder, 1803, *Stelmus* Dujardin, 1845, *Dacnites* Dujardin, 1845\*, *Dachnites* Cobbold, 1858, *Dacnites* v. Beneden, 1858, *Serradacnites* Lane, 1916, *Bulbodacnites* Lane, 1916.

Mouth terminal or somewhat dorsally inclined, sometimes bordered by a striated membrane. Intestinal cæcum absent. Male with a preanal sucker-like organ. Adult worms in the alimentary canal of fishes and tortoises.

Genotype —*Cucullanus curvatus* Muller, 1777.

#### Key to Species

Parasite of tortoise	.	.	<i>serratus</i> , p 221
Parasites of fishes			1
1 Head with a dorsal prominence, female up to 14 mm long			<i>bulbosus</i> , p 222
Head without dorsal prominence, female up to about 7 mm long			<i>callichroi</i> , p 223

\* Törnquist (1931) recognizes *Dacnites* Dujardin as generically distinct from *Cucullanus*. The genotype of *Dacnites* is *D. esuriens* Dujardin, which is placed by Törnquist in the synonymy of *Cucullanus* (s.s.) *heterochrous*. Hence, if the genus *Dacnites* of Törnquist were to be retained, its name would have to be changed. The characters by which it is separated from *Cucullanus* are, however, very slight, and the necessity for the separation appears doubtful.

1. *Cucullanus serratus* (Lane, 1916) Barreto, 1918 (Figs 132 & 133 )

Synonym — *Serradacnitis serrata* Lane, 1916

Host — *Trionyx gangeticus*.

Lane (1916, a) had only male specimens at his disposal \*. These measured 15–16 mm in length. The body is laterally compressed, and has a maximum dorso-ventral diameter of 0.5 mm. There is a rounded "head," measuring 0.55 mm

Fig 132

Fig 133

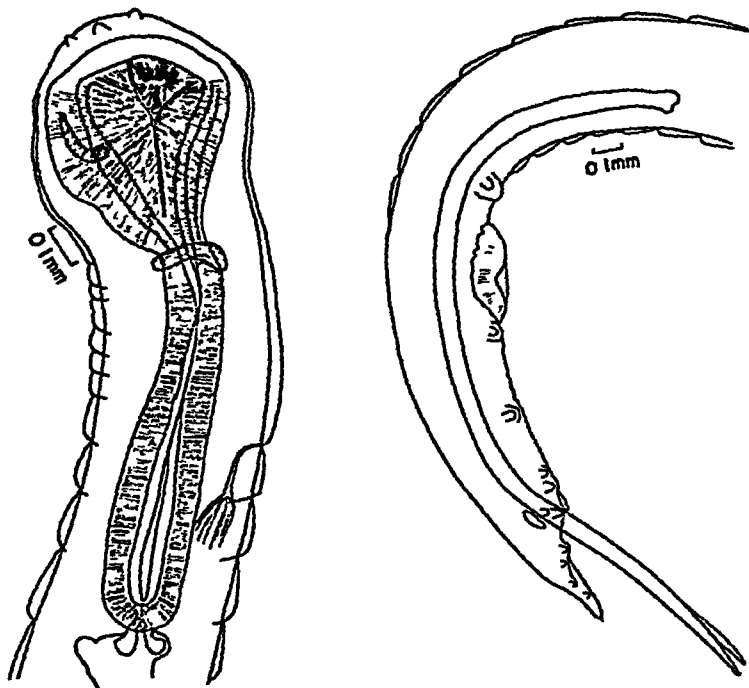


Fig 132 — *Cucullanus serratus* Anterior end, lateral view.  
(After Lane)

Fig 133 — *Cucullanus serratus* Posterior end of male,  
lateral view (After Lane)

in dorso-ventral and 0.45 mm in lateral diameter, and followed by a slight "neck." The cuticular striations are  $5\mu$  apart, and in addition to these there are coarse annulations, 0.095–0.4 mm apart, with prominent posterior edges, giving the outline of the body a serrated appearance. The oesophagus

\* Törnquist (1931) records what he regards as this species from *Trionyx triunguis* from the Sudan, but the males in his material were much smaller, and had spicules less than half as long as those of Lane's specimens. Although the forms described by the two authors are clearly very closely related, it seems uncertain whether they are identical.

measures 1.45 mm in length. The nerve-ring is situated at 0.55 mm, the cervical papillæ at 0.75 mm, and the excretory pore at about 1 mm, from the anterior end.

The tail is 0.35 mm long, and is bluntly conical, with a minute terminal spike. The sucker-like organ is situated at a distance of 1.1–1.4 mm from the posterior end, and measures 0.3 mm in length. There are eleven pairs of caudal papillæ, five of which are preanal, two adanal and four postanal. The eight posterior papillæ on each side are grouped in pairs. The most anterior papilla is just in front of the sucker, the next just behind this organ. The spicules are 3 mm long, and are alate, the shaft and alæ forming a "gutter" which is U-shaped in section. The accessory piece, which measures about 0.09 mm in length, is flattened ventrally and convex dorsally. It is "shield-shaped" in dorso-ventral view, and has a striated appearance.

**2 *Cucullanus bulbosus* (Lane, 1916) Barreto, 1918 (Figs 134 & 135)**

Synonyms — *Bulboducnitis bulbosa* Lane, 1916, *Ducnitis bulbosa* Tornquist, 1931

*Host* — *Caranx melampygus*, Cheval Paar, Gulf of Manaar, Ceylon

The male measures 13.3 mm in length and 0.375 mm in maximum thickness, the female 14 mm and 0.45 mm respectively. The body is laterally compressed. The cuticular striations are 10  $\mu$  apart. The "head" measures 0.45 mm in dorso-ventral and 0.4 mm in lateral diameter, and has a hemispherical bulbous prominence, measuring 0.2 mm in diameter and 0.1 mm in height, on its dorsal aspect. The oesophagus appears, from the figure, to be about 1.7 mm long. The nerve-ring is situated at 0.6 mm from the anterior end.

The tail of the male measures 0.425 mm in length, and ends in a small spike. The sucker-like organ is situated at a distance of 1 mm from the posterior end. Of the eleven pairs of caudal papillæ five are preanal, one adanal and five postanal. The adanal pair is lateral in position, the third pair from the posterior end subdorsal, and the fourth lateral. The papillæ of this last pair are very small. The spicules are 0.7 mm long, and each is "shaped like a somewhat battered kukri," of which the proximal portion of the shaft forms the handle, and the broad alæ the blade. The accessory piece measures about 0.11 mm in length, and is spindle-shaped in lateral view.

The tail of the female is apparently about 0.4 mm long, and is bluntly conical, with a terminal spike. The vulva

is situated at 8 mm from the anterior end, on a hemispherical prominence measuring 0.15 mm in diameter. The vagina runs forward nearly straight for a distance of 1 mm, and then gives off the uterine branches, which at first run anteriorly, and after a course of 0.45 mm become wider. "One uterus eventually turns caudad, and uterine and ovarian coils are found at both ends of the body, reaching to within 0.25 mm from the caudad end of the oesophagus, and 0.16 mm from the anus." The eggs measure  $0.075 \times 0.05$  mm.

Fig 135

Fig 134

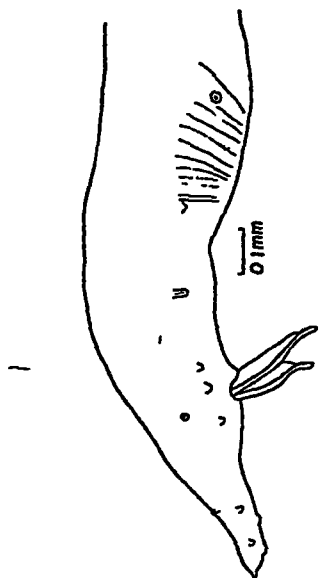
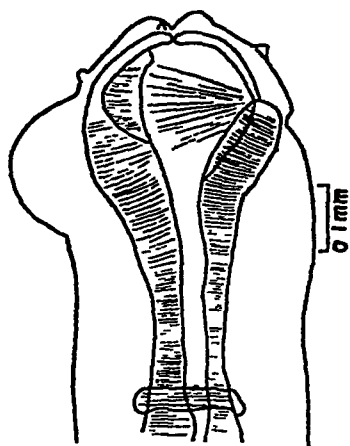


Fig 134 —*Cucullanus bulbosus* Anterior end, lateral view  
(After Lane)

Fig 135 —*Cucullanus bulbosus* Posterior end of male, lateral view  
(After Lane)

### 3 *Cucullanus callichroi* (Stewart, 1914) Barreto, 1922

Synonyms —*Dacnitis callichroi* Stewart, 1914, *Dacnitis callichroi* Lane, 1916

Host —*Callichrous macrophthalmus* (intestine), Lucknow

Of this species Stewart had at his disposal two female specimens only, and these were in a contracted condition. They measured respectively 6.63 mm and 7.225 mm in length and about 0.39 mm and 0.43 mm in thickness. The cuticular striations in the anterior half of the body are  $2\mu$  apart, those in the posterior half  $1.2\mu$ . No striations were seen in the anterior oesophageal region. The body is narrowed in the region corresponding to the anterior two-thirds of the

**œsophagus** The "head" is not curved dorsally, but the mouth is tilted slightly towards the dorsal side. It is bordered by a membranous fringe which bears 32-36 longitudinal striations on each side. The œsophagus measures (from the anterior extremity) up to about 0.77 mm in length.

The tail measures 0.17-0.203 mm in length, and is conical and pointed. It bears a pair of prominent papillæ slightly behind the middle. The anterior lip of the anus is prominent. The vulva is situated at 2.72-3.14 mm from the posterior end. The thick-walled vagina runs forward for a distance of 0.55 mm. The eggs measure up to about  $0.085 \times 0.056$  mm.

## Order DIOCTOPHYMOIDEA Railliet, 1916.

Parasitic forms of medium or large size Mouth hexagonal, without lips, but surrounded by one, two or three circles each of six papillæ Oesophagus relatively long and simple or club-shaped Cuticle of body sometimes spiny Each of the four muscular fields divided longitudinally into two by the insertion of well-developed suspensory muscles of the alimentary canal Caudal end of male provided with a muscular bursa-like expansion, without rays A single long spicule present Anus of female terminal Female genital tube single Eggs barrel-shaped, with a thick, irregular albuminous coating and not containing embryos when laid Adults parasitic in mammals and birds Larval forms in an intermediate host

### 7. Family DIOCTOPHYMIDÆ Railliet, 1916.

With the characters of the Order

#### *Key to Genera*

Adults parasitic in mammals	Vulva near anterior end of body	DIOCTOPHYME, p 225
Adults parasitic in birds	Vulva near posterior end of body	EUSTRONGYLIDES, p 227.

#### 1 Genus DIOCTOPHYME Collet-Meygret, 1802

Synonym — *Eustrongylus* Diesing, 1851

Extremely large worms (female up to about 1 m long, male about one-third of this length) Body blood-red during life, truncate posteriorly and somewhat tapering anteriorly. Cuticle relatively thin and transparent, transversely striated but without spines Mouth surrounded by two circles of papillæ Vulva towards the anterior end of the body Adult worms in the kidneys or serous cavities of mammals, larvæ, so far as known, in the musculature of freshwater fishes.

Genotype — *Dioclophyme renale* (Goeze, 1782)

# 1 *Diectophyme renale* (Goeze, 1782) Stiles, 1901 (Fig 136)

Synonyms — *Ascaris renalis* Goeze, 1782, *Ascaris canis* Schrank, 1788, *Ascaris martis* Schrank, 1788, *Ascaris visceralis* Gmelin, 1790, *Strongylus gigas* Rudolphi, 1802, *Fusaria visceralis* Zeder, 1803, *Fusaria renalis* Zeder, 1803, *Lumbricus renum canis* Rudolphi, 1809, *Eustrongylus gigas* Diesing, 1851, *Lumbricus canis renalis* Diesing, 1851, *Lumbricus martis renalis* Diesing, 1851, *Lumbricus sanguineus* Diesing, 1851, *Lumbricus gulonis sibirici* Diesing, 1851, *Lumbricus renalis* Küchenmeister, 1855, *Strongylus renalis* Moquin-Tandon, 1860, *Eustrongylus gigante* Perroncito, 1882, *Eustrongylus visceralis* Railliet, 1885, *Diectophyme gigas* Stiles and Hassall, 1894, *Diectophyme visceralis* Stiles and Hassall, 1896, *Eustrongylus renalis* Guiart, 1910, *Diectophyme renalis* Castellani and Chalmers, 1910; *Diacunculus longissimus* Césalpin (*teste* Blanchard, 1888)

**Hosts** — This worm is most frequently found in the dog, but occurs also in many other carnivores, including the

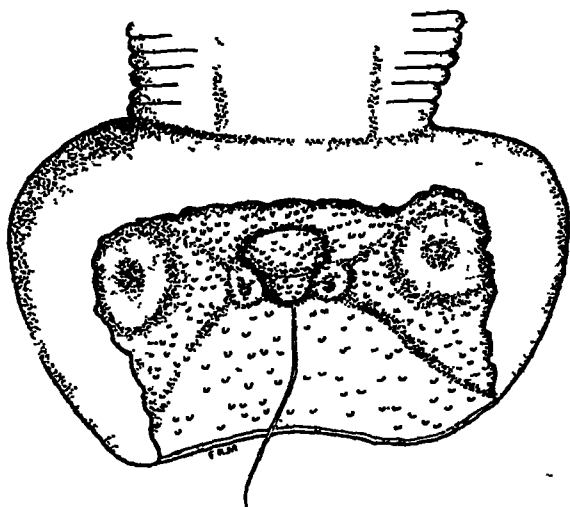


Fig 136 — *Diectophyme renale* Posterior end of male, ventral view.  
(From Baylis, after Stefanski)

wolf, fox, cat and seal, the otter and various other members of the weasel tribe. It has also been recorded as an occasional parasite of the pig, horse, ox, orang-utan and man. Its geographical range includes Europe, Asia and North and South America. In India it has been recorded occasionally from the dog (Punjab Gauger, 1910, 1915; Bihar Roy Chaudhuri, 1931). The usual habitat of the adult worm is the pelvis of the kidney, from which it may invade the body of the organ and gradually destroy the renal tissue. Sometimes, however, it is found either free or encapsuled in the abdominal or thoracic cavity, or in the liver. In dogs its presence sometimes induces nervous symptoms which simulate those of rabies.

This is the largest known Nematode, the male measuring 14–15 cm in length and 3–7 mm in maximum thickness, the female 15–103 cm and 5–12 mm respectively. The body is blood-red when fresh. Each lateral line bears a row of papillæ. These become closer together towards the extremities of the body. The mouth is surrounded by two crowns of papillæ, those of the outer crown being situated on relatively large nodular swellings, while those of the inner crown are small. On the ventral surface, behind the mouth, there is a short longitudinal depression with rather prominent borders. The œsophagus is about 45 mm long in the male and 50–60 mm in the female, and attains a thickness of about 2 mm. The intestine, according to Lukasiak (1930) shows a division into three portions of different colours and thicknesses, the middle portion being short and narrow, the posterior portion very wide.

The posterior end of the male is provided with a "bursa" which is of a transversely-elongated oval shape, slightly indented on its anterior margin, and covered on its inner surface with small papilliform elevations. In the centre of the "bursa" there is a somewhat raised cone, at the summit of which is the cloacal aperture. The spicule is bristle-like and is usually said to measure 5–6 mm in length. This, however, probably refers only to the protruded portion, since Lukasiak gives the total length of the spicule as 12–14.5 mm, 7.5 mm of this being retained within the spicule-sheath.

The anus of the female is crescentic, and near it there are some small papillæ. The vulva, which is transversely elongate, is situated at 14–80 mm from the anterior extremity, according to the size of the specimen, but usually behind the posterior end of the œsophagus. The muscular vagina measures up to about 30 mm in length, and may run at first either anteriorly or posteriorly from the vulva. The eggs have a thick, coarsely pitted or mammillated albuminous covering when laid, and measure  $0.064\text{--}0.084 \times 0.04\text{--}0.052$  mm.

The life-history of this parasite is not yet fully known, but evidence has been brought forward by Ciurea which suggests that one of its intermediate hosts in Europe is the freshwater fish *Idus idus*.

## 2 Genus EUSTRONGYLIDES Jägerskiöld, 1909

Forms of medium or rather large size. Body cylindrical, or sometimes swollen in its middle. Cuticle coarsely striated; at least towards the extremities, but without spines. Mouth surrounded by two or three circles of papillæ. Vulva close

to the anus. Adult worms in the alimentary canal of birds (usually in the glands of the proventriculus); larvæ in the connective tissue of fishes, and apparently in Crustacea.

Genotype :—*Eustrongylides tubifex* (Nitzsch, 1819)

### 1. *Eustrongylides* sp

Baylis and Daubney (1922) tentatively refer to this genus two larvæ taken from a prawn at Karachi. These measured respectively 12.5 mm and 13.25 mm in length and 0.26 mm and 0.33 mm. in maximum thickness. The "head" was somewhat swollen and almost globular, and had a maximum diameter of 0.21–0.22 mm. The mouth was situated in a large depression, on the border of which only one ring of six papillæ was seen. The oesophagus measured 7.9 mm. and 8.25 mm. in length (about two-thirds of the total length). It had a short, narrow, muscular anterior portion, measuring 0.43–0.45 mm. in length, and a considerably wider, glandular posterior portion. The tail was 0.13–0.15 mm. long, and was bluntly conical, with a small terminal cuticular "button".

## Order TRICHINELLOIDEA Hall, 1916.

Medium-sized or small forms in which the body is usually elongate and slender, and is more or less clearly divided into an oesophageal portion and a posterior portion containing the other organs. Oesophagus narrow and partially embedded in a conspicuous "cell-body" consisting of a single chain of cells. Cloacal aperture of male and anus of female terminal or subterminal. Male with a single spicule or without a spicule. Female genital tube single.

### 8. Family TRICHINELLIDÆ Stiles and Crane, 1910.

With the characters of the Order.

#### Subfamily TRICHINELLINÆ Ransom, 1911

Male without spicule or spicule-sheath. Vulva in the oesophageal region. Female ovoviviparous. Eggs spherical, without a true shell but surrounded by a delicate membrane. Adult worms in the intestine of mammals, giving rise to larvæ which become encapsuled in the musculature of the same host.

#### 1 Genus TRICHINELLA Raillet, 1895.

Synonyms —*Trichina* Owen, 1835, *nee* Meigen, 1830, *Trichine* Bischoff, 1840, *Trichina* Bischoff, 1840, *Trichinus* Bischoff, 1840.

With the characters of the Subfamily.

Genotype —*Trichinella spiralis* (Owen, 1835).

#### 1 *Trichinella spiralis* (Owen, 1835) Raillet, 1895. (Fig. 137)

Synonyms —*Trichina spiralis* Owen, 1835, *Trichina spiralis* Bischoff, 1840, *Trichina spiralis* Bischoff, 1840; *Trichina affinis* Diesing, 1851 (part), *Trichina spiralis hominis* Kraemer, 1853, *Trichina circumflexa* Polono, 1860, *Trichina pseudalius* Dengler, 1863; *Pseudalius trichina* Davaine, 1863, *Trichine spirale* Bert and Blanchard, 1885, ? *Trichina canis* Kraemer, 1853.

*Hosts* —This parasite has been recorded from a very wide

variety of mammalian hosts. These include man, the pig, ox, sheep, horse, dog, cat, rabbit, rat and many other animals. The adult worms occur in the small intestine of the host, and the larvæ become encysted in the fibres of the voluntary muscles. The distribution of the species is world-wide, and

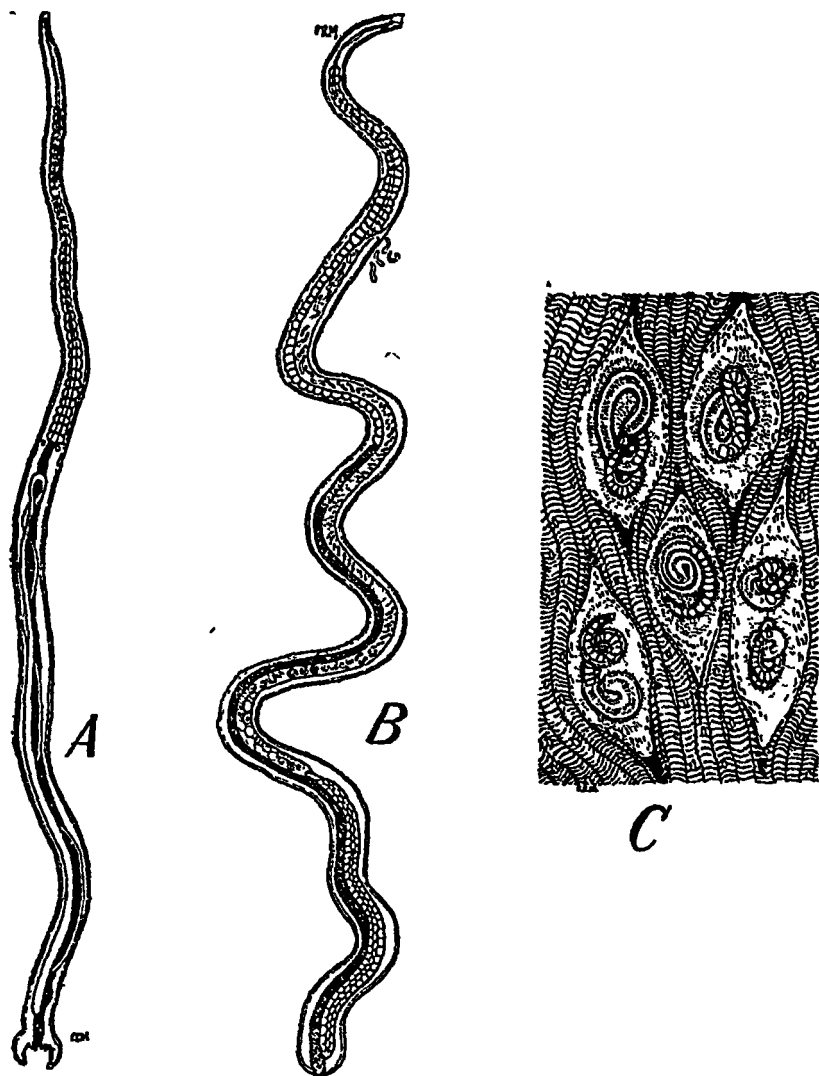


Fig 137—*Trichinella spiralis* A, adult male, B, adult female, C, larvæ encapsuled in muscle (From Baylis, after Fiebiger)

it still occurs not uncommonly in man in countries where pork or other flesh is eaten in a raw or very slightly cooked state. Its incidence has, however, been materially reduced

where a rigorous system of meat-inspection has been enforced. Although this worm appears to have been known to occur formerly in man in India, no recent references to it have been found in the literature. It is to be presumed, therefore, that it is by no means prevalent, or that infestations with it, when they occur, are so slight as to pass unnoticed.

The male measures 1.4–1.6 mm. in length and about 0.04 mm. in maximum thickness, the female 3–4 mm. and 0.06 mm. respectively. At the posterior end of the body, in the male, there is a pair of relatively large, ventrally-directed, conical processes at the sides of the cloacal aperture, and between these two pairs of papillæ. The vulva is situated near the middle of the oesophageal region of the body. The subglobular eggs measure about  $0.04 \times 0.03$  mm. The embryos, on hatching, measure 0.09–0.16 mm. in length and  $6\text{--}9\mu$  in thickness, the greatest diameter being near the anterior end.

The life-history of this species may be summarized as follows. After copulation, which takes place in the small intestine of the host, the male dies. The fertilized female burrows into the mucous membrane by way of the glands of Lieberkühn, and makes its way into the lymph-spaces. Here it produces a large number of embryos, which migrate by way of the lymphatics and blood-vessels all over the body, many of them thus reaching the connective tissue of the musculature. Those which have entered the voluntary muscles (especially those of the diaphragm, thoracic wall, tongue, throat and eyes) penetrate into the sarcolemma of the muscle-fibres, and grow to a size of  $0.8\text{--}1\text{ mm} \times 0.03\text{ mm}$ , their shape changing at the same time so that the anterior end becomes slender, the posterior thick and blunt. Finally they become enclosed in lemon-shaped capsules, each of which usually contains a single worm, but may occasionally contain as many as seven. At this stage the larvæ are infective for any suitable host which ingests the flesh containing them, and may remain alive and infective for as long as eleven years, or possibly longer. If not ingested during this period, the larvæ die and their cysts become calcified.

When liberated from the capsule by digestion, the larva undergoes its final moult and becomes sexually mature within one to five days. Heavy infestation is dangerous because the muscles invaded by the larvæ may undergo degeneration, and death may occur from paralysis of the respiratory muscles.

## Subfamily TRICHURINÆ Ransom, 1911

A ventral longitudinal "bacillary band" present at least in the œsophageal region, composed of numerous unicellular subcuticular glands with rod-like processes projecting through the cuticle. Similar bacillary bands may be present on the dorsal and lateral surfaces of the body. Male with a single spicule or, exceptionally, without a spicule. A protrusible, membranous spicule-sheath present, the lining of which (the outer surface when everted) may be smooth or spiny. Vulva behind the junction of the œsophagus and intestine. Eggs barrel-shaped or lemon-shaped, with thick shells having an opening at each pole, closed by a plug, their contents unsegmented at the time of laying.

*Key to Genera*

- |  |                   |
|--|-------------------|
| Posterior portion of body usually shorter and stouter than œsophageal portion. Caudal end of male curled dorsally.                               | TRICHURIS, p 232  |
| Posterior portion of body usually longer and scarcely stouter than œsophageal portion. Caudal end of male straight or curved ventrally . . . . . | CAPILLARIA, p 240 |

## 2 Genus TRICHURIS Roederer, 1761

Synonyms \*.—*Trichocephalus* Goeze, 1782, *Trichurus* Herbst, 1787, *Trichocephalus* Schrank, 1788, *Mastigodes* Zeder, 1800; *Tricurus* Bradley, 1813; *Mastigoides* Lamarck, 1816, *Trichocephalus* Baelz, 1883, *Trichocephalus* Wichmann, 1889, *Trichurus* Fagge and Pye-Smith, 1902, *Trichocephalus* Kahane, 1907, *Trichuria* Gage and Bass, 1910, [not *Trichurus* Linnæus, 1758]

Body with slender œsophageal portion and thicker and shorter posterior portion. A ventral longitudinal bacillary band present in the œsophageal region. Posterior extremity bluntly rounded in both sexes, that of the male curled dorsally and without alæ or bursa-like structure. A spicule present. Adult worms in the cæcum of mammals, forming burrows in the epithelium, in which the anterior end is buried.

Genotype.—*Trichuris trichiura* (Linnæus, 1771).

*Key to Species*

- |  |                          |
|--|--------------------------|
| Parasite of Primates and swine   | <i>trichiura</i> , p 233 |
| Parasites of ruminants   | 1                        |
| 1 Spicule of male less than 3 mm long  | <i>discolor</i> , p 239  |
| Spicule more than 3 mm long  | 2                        |
| 2 Spines on distal expansion of everted spicule-sheath shorter than the rest. Vagina long, slender and sinuous, its lumen widening gradually                                   | <i>ovis</i> , p. 235     |
| Spines on distal expansion of everted spicule-sheath longer than the rest. Vagina short and stout, its lumen forming angular bends, and expanding suddenly into an egg-chamber | <i>globulosa</i> , p 238 |

\* Some obvious misprints are omitted

1 *Trichuris trichiura* (Linnæus, 1771), Stiles, 1901. (Figs 138 & 139)

Synonyms.—*Ascaris trichiura* Linnæus, 1771, *Trichocephalus hominis* Schrank, 1788, *Trichocephalus suis* Schrank, 1788, *Trichocephalus apri* Gmelin, 1790, *Trichuris hominis* Bruguière, 1791, *Trichuris vulgaris* Hooper, 1799, *Trichuris intestinalis* Hooper, 1799, *Trichocephalus hominis* Lamarck, 1801; *Trichocephalus dispar* Rudolphi, 1802, *Mastigodes apri* Zeder, 1803, *Trichocephalus crenatus* Rudolphi, 1809, *Trichocephalos hominis* Baird, 1853, *Ascaris trichina* Moquin-Tandon, 1860; *Trichocephalus trichiurus* Blanchard, 1895, *Trichocephalus dispar* Daniels, 1897, *Trichocephalus trichiurus* Simon, 1907, *Trichocephalus dispar* Kahane, 1907, *Trichuris suis* Smith, 1908, *Trichuris crenata* Godoelst, 1911, *Trichurus trichiura* Castellani and Chalmers, 1913, *Trichocephalus trichiurus* da Matta, 1914, *Trichocephalus trichiura* Mukerji and Dass, 1915, *Trichocephalus trichiurus* Maxwell, 1916, *Trichocephalus trichiurus* Bhalerao, 1935

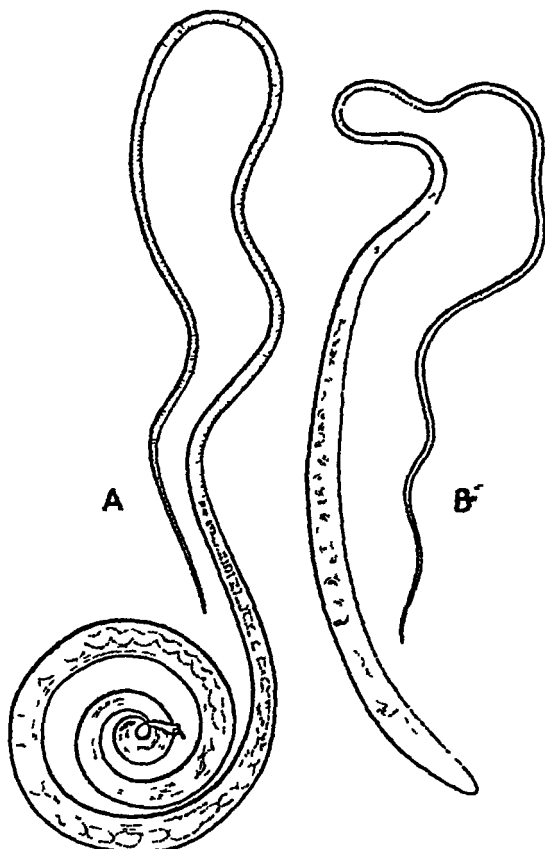


Fig 138—*Trichuris trichiura* A, male; B, female  
(Partly after Bremser)

*Hosts*.—This species occurs in man, in various other

Primates and in swine It inhabits the cæcum, colon and appendix, and is of cosmopolitan distribution In India, besides its common occurrence in man \*, it has been recorded by Baylis and Daubney (1922) from a gibbon (*Hylobates* sp) and from a wild boar (*Sus cristatus* [= *S bengalensis*]), the latter near Dinapore, Bihar Maplestone (1903, a) lists it among parasites found in pigs slaughtered in Calcutta The specimens recorded by Chandler (1930) from the hanuman monkey (*Semnopithecus entellus*) were also presumably of Indian origin

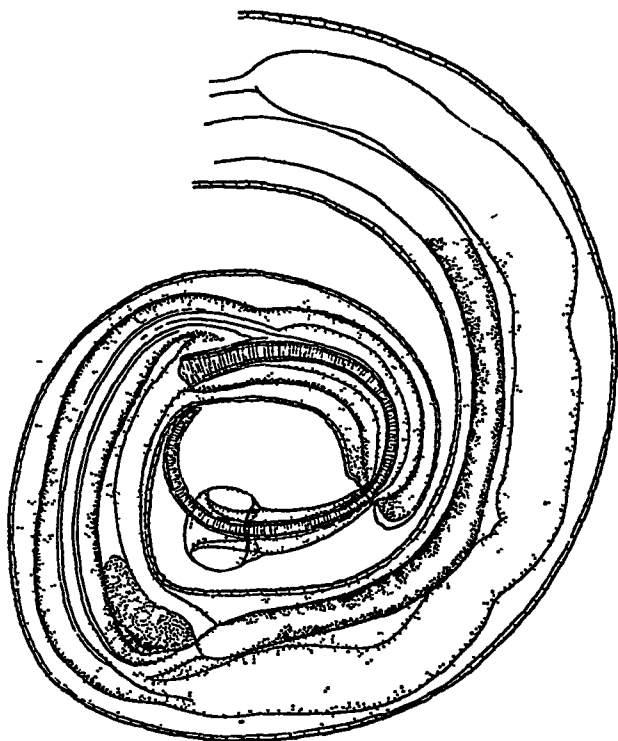


Fig. 139 — *Trichurus trichura* Posterior end of male, lateral view (After Sprehn)

The male measures about 30–45 mm in length and 0.45–0.65 mm in maximum thickness, the female 35–50 mm and 0.5–0.85 mm respectively. The slender oesophageal portion of the body occupies about two-thirds to three-fifths of the total length. The spicule of the male measures 2–3.35 mm in length and about 0.056 mm in maximum thickness (near the root, which is slightly expanded) Its tip may be rounded or pointed The spicule-sheath is variable in shape when

\* Sweet (1929), for example, records that about 14 per cent of the population of Mysore State are infested

extruded, being sometimes cylindrical, sometimes expanded distally, and may be partly or wholly covered with spines. The ejaculatory duct, according to Chandler (1930), is about 2.9–3.4 mm long, and hardly more (sometimes much less) than half as long as the vas deferens, with which it is connected by a narrow duct about 0.5 mm long. The testis is closely convoluted throughout its length.

The vulva is not prominent. The eggs measure 0.05–0.056 × 0.021–0.025 mm. When laid they are almost colourless, but when seen in faeces they are usually dark reddish-brown.

The development of the embryos does not begin until the eggs have left the body of the host. In cool climates development to the infective stage may take from six to twelve months, but in warmer climates it takes only from three weeks to a month. The eggs are highly resistant to cold, and can withstand freezing. They may remain infective for as long as five years. If they are ingested, with food or water, by a suitable host, the larvae hatch and are said to pass at once into the mucosa of the intestine, reaching maturity within a month after infection.

## 2 *Trichuris ovis* (Abildgaard, 1795) Smith, 1908 (Figs 140 & 141, A)

Synonyms — *Trichocephalus ovis* Abildgaard, 1795, *Trichocephalus affinis* Rudolphi, 1802, *Mastigodes affinis* Zeder, 1803, *Trichocephalus affinis* Francis, 1894, *Trichuris affinis* Stiles, 1902, \* *Trichocephalus camel* Rudolphi, 1819\*, ? *Trichocephalus echinophallus* Nitzsch, in Creplin, 1849, ? *Trichocephalus echinophyllus* Railliet, 1893, ? *Trichocephalus alcocki* v. Linstow, 1906, ? *Trichuris alcocki* Ransom, 1911, ? *Trichuris camel* Ransom, 1911.

*Hosts* — This is a common and widely-distributed parasite of the sheep, goat, ox, camel and many other ruminants. Gaiger (1910, 1915) records it as common in sheep, goats and cattle (especially the first) in the Punjab. Bhalariao (1935, b) records it, presumably from the same hosts, from Bombay, the Central Provinces and Madras. Specimens were recorded by Baylis and Daubney (1922) from an "antelope"—probably the Indian antelope or black buck (*Antelope cervicapra*). The thomeng (*Cervus eldi*) is also a host for this species, since specimens of *T. ovis* were included in the material named *T. alcocki* by v. Linstow (1906, e) and obtained from this

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\* "*T. camel* Rud" has been recorded from both the Bactrian camel and the dromedary. According to Gaiger (1910) Leese found it in the latter host in India. Rudolphi (1819) gives no description of the worm. His species is therefore unrecognizable, and it is uncertain whether the forms seen by later authors were the same. In all probability *T. camel* is identical with either *T. ovis* or *T. globulosa*.

animal in the Zoological Gardens, Calcutta\*. As the writer (1932, a) has shown, *Trichuris globulosa* (v. Linstow, 1901) is probably as common as *T. ovis* in domestic ruminants

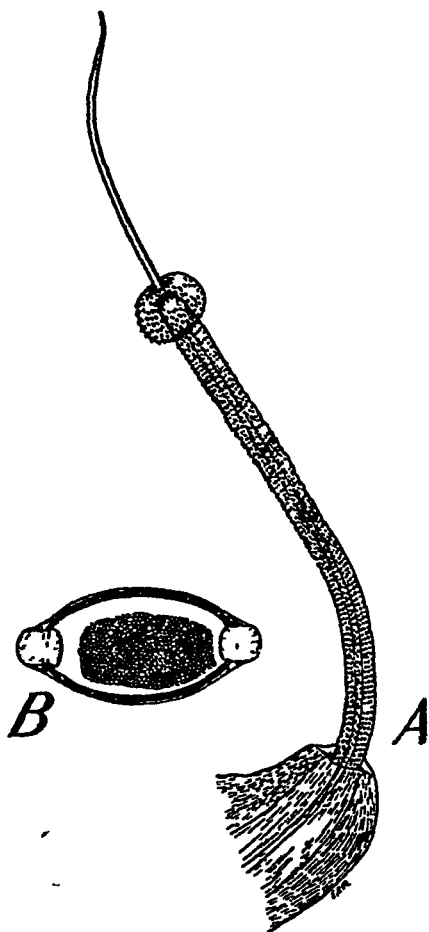


Fig 140 — *Trichuris ovis* A, posterior end of male, lateral view, B, egg. (From Baylis, after Ransom.)

in parts of Africa, and it is not improbable that the two species have been confused elsewhere.

\* Sprehn (1927) states that he has examined the original specimens of *T. alcocki*, consisting of one male and several females, deposited in Berlin, and found them to be identical with *T. globulosa*. Through the courtesy of the Director of the Zoological Survey of India, the writer has been able to examine a considerably larger number of specimens, being that part of the original material which remains in the Indian Museum, Calcutta. This proves to be a mixture of *T. globulosa* and *T. ovis*. As v. Linstow states that the spicule of the male in *T. alcocki* is only 3 mm long and 7.8  $\mu$  thick, it seems probable that the male described by him was an immature specimen of *T. ovis* rather than *T. globulosa*. However, the description is insufficient to establish definitely of which species *T. alcocki* is a synonym, and it is accordingly mentioned under both.

Both sexes of *T. ovis* measure about 50–80 mm in length. The maximum thickness of the male is about 0.5 mm, that of the female about 1 mm. In the male the slender cesophageal region of the body occupies about three-quarters, in the female two-thirds to four-fifths, of the total length. The marginal rods of the bacillary band are larger than the rest.

The spicule of the male varies in length between 4.9 mm and 7.2 mm, with an average of about 5.8 mm, and is somewhat thickened distally before tapering to a point. The

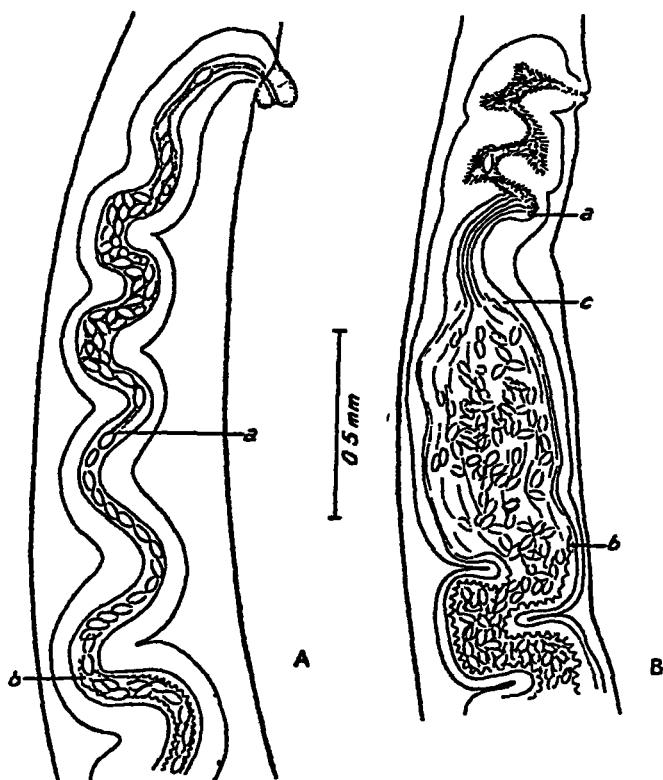


Fig 141—A, *Trichuris ovis*; B, *Trichuris globulosa*. Vulvar region of female; lateral view. For explanation of lettering, see text. (After Baylis.)

thickness of the spicule at about the middle of its length varies between  $10\mu$  and  $40\mu$ , with an average of about  $27\mu$ . The spicule-sheath, when fully everted, has a globular expansion at its distal end. The whole sheath is covered with small spines, those on the expansion being smaller than the rest.

The vagina is relatively long and slender, and pursues a regular, sinuous course, its muscular wall gradually widening

posteriorly There is no sudden expansion into an egg-chamber, as in *T. globulosa* The lumen of the distal portion is lined with fine spines for a distance of at least 1 mm (fig 141, A, c), and part of this spiny lining is frequently everted at the vulva The eggs measure 0.07–0.08 mm. in length, including the polar plugs, or 0.055–0.065 mm without them, and 0.03–0.042 mm in width When found in the fæces of the host they are of a dark brown colour.

3 *Trichuris globulosa* (v Linstow, 1901) Ransom, 1911.  
(Figs 141, B, & 142)

Synonyms \* —*Trichocephalus globulosus* v Linstow, 1901, ? *Trichocephalus cameli* Rudolphi, 1819, ? *Trichocephalus echinophallus* Nitzsch, in Creplin, 1849, ? *Trichocephalus echinophyllus* Railliet, 1893, ? *Trichocephalus alcocki* v Linstow, 1906, ? *Trichuris alcocki* Ransom, 1911, ? *Trichuris cameli* Ransom, 1911

*Hosts* —This species was originally recorded from the dromedary, but is known † to occur also in cattle, sheep and

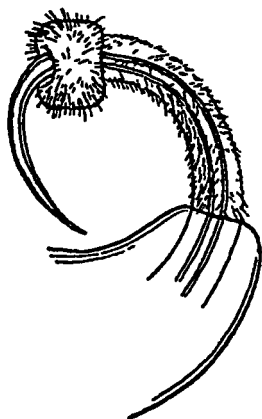


Fig 142 —*Trichuris globulosa* Posterior end of male, lateral view  
(After v Linstow)

goats, and in the European elk and chamois. The specimens named *Trichocephalus alcocki* by v. Linstow (1906, e), from a thameng (*Cervus eldi*) in the Zoological Gardens, Calcutta, belonged partly, as already mentioned under *T. ovis*, to this species

Both sexes measure about 40–70 mm in length. The maximum thickness of the body in the male is about 0.71 mm, in the female about 0.87 mm. The slender oesophageal portion of the body occupies about two-thirds of the total

\* See foot-notes to *T. ovis*, pp 235 & 236

† See Sprehn (1927), Baylis (1932, a)

length in the male, and three-quarters in the female. The cuticular striations, according to v. Linstow, are at intervals of about  $3\mu$ .

The spicule of the male, according to the writer's (1932, a) observations, varies in length between 3.8 mm and 5.7 mm, with an average of about 4.8 mm. Its thickness, at about the middle of its length, varies between  $32.5\mu$  and  $50\mu^*$ , with an average of about  $39.3\mu$ . As in *T. ovis*, there is a considerable thickening of the spicule before the tip. The "flare" at the root is usually less pronounced than in that species. The spicule-sheath, when fully everted, has a globular expansion at the distal end. The sheath is covered with spines, which are longer and more closely set than in *T. ovis*, those on the distal expansion being considerably longer than the rest.

The vagina is relatively short, stout and muscular. The lumen of its distal portion is lined with large, coarse spines, and is thrown into three or four sharp, angular bends (fig 141, B). The portion of the vagina immediately behind this spiny region forms, when not distended with eggs, a narrow duct (a-c), lined with cuticle and curved so that its concavity is ventral. This duct expands suddenly into a large egg-reservoir (c-b), with a folded cuticular lining. Eversion of the spiny lining at the vulva, if it occurs, is not commonly observed. The eggs appear to be indistinguishable from those of *T. ovis*. According to v. Linstow their length, including the polar plugs, is 0.068 mm, or without them 0.06 mm, and their width 0.036 mm.

#### 4 *Trichuris discolor* (v. Linstow, 1906) Ransom, 1911 (Fig 143)

Synonyms —*Trichocephalus discolor* v. Linstow, 1906, *Tricuris discolor* Taylor, 1924

*Hosts* —This species was briefly described by v. Linstow (1906, d) and recorded from the zebu (*Bos indicus*) at Colombo, Ceylon. It is said to have occurred in the stomach. The type-specimens do not appear to be available in the Colombo Museum. Taylor (1924, a) records the worm from a cow in England, and gives a description which agrees closely with that of v. Linstow.

The male measures about 45–59 mm in length and 0.55–0.75 mm in maximum thickness, the female about 43–52 mm and 0.67–0.83 mm respectively. The slender oesophageal portion of the body occupies about two-thirds of the total length in the male, and three-quarters in the female. The cuticular striations are at intervals of about

\* According to Sprehn (1927), 80–90  $\mu$

7.5–9.1  $\mu$ , and give the anterior portion a serrated appearance in optical section. According to Taylor, there are two lateral vesicular swellings at the anterior extremity.

The spicule of the male measures 1.76–2.3 mm in length and about 10–12  $\mu$  in thickness, and has a rounded tip. The

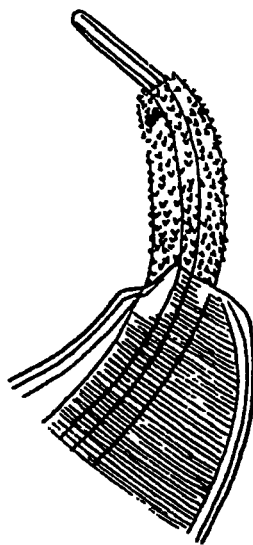


Fig. 143 — *Trichurus discolor*. Posterior end of male, lateral view.  
(After v. Linstow.)

spicule-sheath is covered with spines, these being larger than in *T. ovis* but less closely set.

The eggs measure 0.06–0.073 mm in length, including the large, rounded polar plugs, or 0.043–0.046 mm. without the plugs, and 0.03–0.033 mm in width.

### 3. Genus **CAPILLARIA** Zeder, 1800.

Synonyms — *Trichosoma* Rudolphi, 1819, *Trichosomum* Creplin, 1829, *Trichostoma* Westwood, 1851, *Thomins* Dujardin, 1845, *Eucoleus* Dujardin, 1845, *Calodium* Dujardin, 1845; *Laniscus* Dujardin, 1845; *Hepaticola* Hall, 1916, *Hepaticula* Urioste, 1923.

Body typically very slender. Œsophageal portion usually shorter and only slightly thinner than the posterior portion. A ventral bacillary band present, usually also a similar dorsal band, and sometimes a pair of lateral bands. Caudal end of male straight or slightly curved towards the ventral side, frequently provided with delicate alæ or a bursa-like structure, or both. A spicule usually present, sometimes very slightly chitinized or absent. Vulva close behind the junction of the Œsophagus and intestine, often provided

with a protrusible, membranous, funnel-like structure. The egg-shells may be smooth or variously ornamented. Adult worms in the alimentary canal, liver, urinary bladder or respiratory passages of vertebrates.

Genotype — *Capillaria anatis* (Schränk, 1790).

### Key to Species

Parasitic in the intestine of pigeons and other birds	<i>columbæ</i> , p 241
Parasitic in the liver of rodents and other mammals	<i>hepatica</i> , p 242
Parasitic in the abomasum of cattle	<i>bilobata</i> , p 245

### 1 *Capillaria columbæ* (Rudolphi, 1819) Travassos, 1915 (Fig 144)

Synonyms — *Trichosoma columbæ* Rudolphi, 1819, *Calodium tenue* Dujardin, 1845, *Trichosomum (Calodium) tenuissimum* Diesing, 1851, *Trichosomum tenuissimum* Eberth, 1863, nec Loidy, 1891, *Trichosoma tenuissimum* v. Lanstow, 1874, *Trichosomum columbæ* Neveu-Lemaire, 1912, *Capillaria dujardini* Travassos, 1914

**Hosts** — This species occurs in the small intestine of the domestic pigeon, fowl and turkey in many parts of the world.

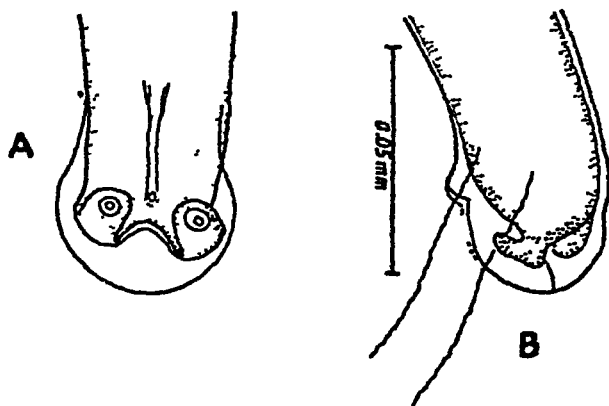


Fig. 144 — *Capillaria columbæ*. Posterior end of male. A, ventral view; B, lateral view (After Teixeira de Freitas and Lins de Almeida)

In India it has been recorded from the pigeon (Baylis and Daubney, 1922), and there are specimens in the British Museum (Natural History) from the same host from Colombo, Ceylon.

The following description is taken mainly from Irwin-Smith (1920), Morgan (1932, a) and Teixeira de Freitas and Lins de Almeida (1936). The male measures about 8.4–11.8 mm in length and 0.025–0.064 mm. in maximum thickness, the female about 10.5–19 mm., and 0.03–0.09 mm.

respectively. A narrow ventral and two well-developed lateral bacillary bands are present, each of the latter having a width equal to one-quarter or one-third of the diameter of the body. The œsophagus is about 4–6 mm long. The nerve-ring is situated at about 0.08–0.16 mm from the anterior extremity.

The caudal end of the male is provided with a rounded bursa-like membrane, supported by a pair of L-shaped processes, each of which bears a terminal papilla. The spicule measures 1.2–1.57 mm in length and  $5\text{--}12\mu$  in maximum thickness. It has a bluntly rounded tip and an expanded root. The spicule-sheath is transversely wrinkled but without spines.

The posterior end of the female is bluntly rounded. The vulva is situated at a distance of 0.06–0.17 mm (or 0.026 mm according to Irwin-Smith) behind the junction of the œsophagus and intestine. Its anterior lip is slightly prominent. There is apparently no protrusible membrane. The eggs measure  $0.041\text{--}0.056 \times 0.022\text{--}0.026$  mm. According to the writer's observations they measure up to 0.056 mm in length, including the polar plugs, or 0.052 mm excluding them, and the shells are rather barrel-shaped and thick, with a granular pattern. Miller (1937) records a maximum length of 0.072 mm.

This species appears to be, at times, highly pathogenic, heavy infestations producing an enteritis which may cause serious losses in pigeon-lofts.

## 2 *Capillaria hepatica* (Bancroft, 1894) Travassos, 1915. (Figs 145–147)

Synonyms — *Trichosomum tenuissimum* Leidy, 1891, *nec* Diesing 1851, *nec* Eberth, 1863, *Trichocephalus hepaticus* Bancroft 1894, *Trichosomum hepaticum* Raillet, 1898, *Trichosoma hepaticum* Galli-Valerio, 1901; *Capillaria leidy* Travassos, 1915, *Hepaticola hepatica* Hall, 1916, ? *Hepaticola anthropopitheci* Troisier, Deschiens, Limousin and Delorme, 1928.

*Hosts*.—This worm is known principally as a parasite of rats, but worms or eggs which are probably attributable to this species have been recorded from a wide variety of other mammals, chiefly rodents. *C. hepatica* appears to occur occasionally as an accidental parasite of man, the first case of this kind having been recorded from India by Dive, Lafrenais and MacArthur (1924). The worms inhabit the liver of their hosts, where they deposit masses of eggs, often visible as yellowish patches just beneath the capsule. Frequently these eggs are the only indication of infection, the worms disappearing after oviposition.

Owing to the habitat of the worms and the difficulty of extracting them without damage, complete specimens are

rarely obtained Bancroft (1894) gives their length as 1½–2 inches (about 40–50 mm) An immature female specimen obtained by the writer (1931) was about 38 mm long The maximum thickness of the male is 0.065–0.07 mm, and that of the female 0.1–0.23 mm The thickest portion of the oesophageal region is followed, in the female, by a narrower

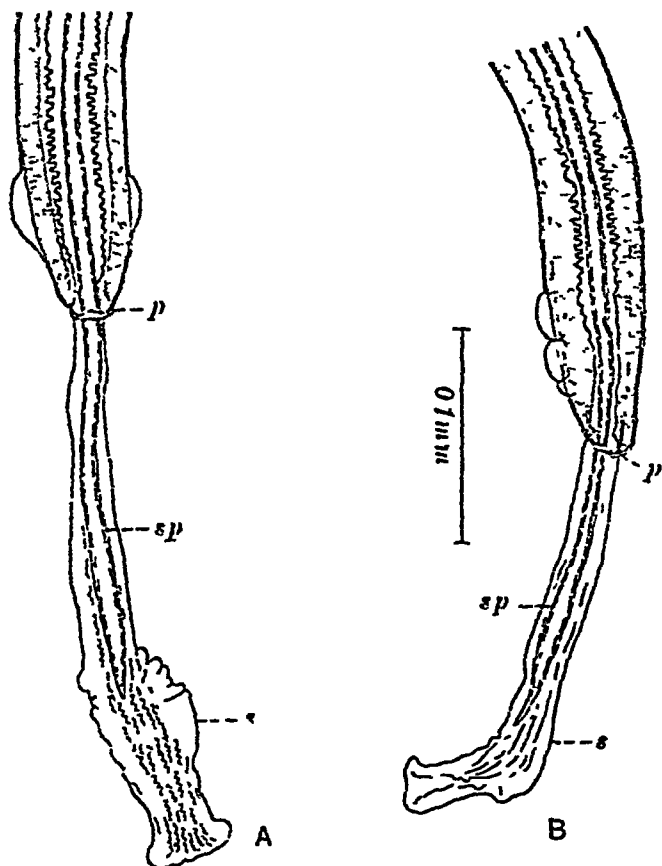


Fig 145—*Capillaria hepatica* Posterior end of male, with spicule and sheath protruded. A, dorsal view, B, lateral view *p*, papilla, *s*, spicule-sheath; *sp*, spicule (After Baylis, in 'Parasitology')

region in which the vulva and vagina are situated. Well-developed dorsal and ventral bacillary bands are present The oesophagus is about 5.2–6.7 mm long in the male, and 6.3–9.9 mm in the mature female

The posterior extremity of the male is blunt and without alae It bears a pair of slight subventral lobes behind the

cloacal aperture, and at the base of each of these lobes there is a papilla. As was shown by the writer (1931), there is a well-developed though rather slightly chitinized spicule, measuring 0.425–0.5 mm in length. It is cylindrical for the greater part of its length, but has a slight expansion at its root and a slight fusiform thickening towards its distal end. Its tip tapers to a fine point. The spicule-sheath is membranous and protrusible, and when fully everted may be expanded distally into a large, funnel-shaped dilatation. The sheath is apparently without spines.

The vulva is provided with a protrusible, membranous, funnel-like structure. The average length of the eggs, including the polar plugs, is about 0.063 mm, and their average width about 0.032 mm. Their extreme measurements, as given by various authors, are 0.04–0.078 × 0.026–0.045 mm.

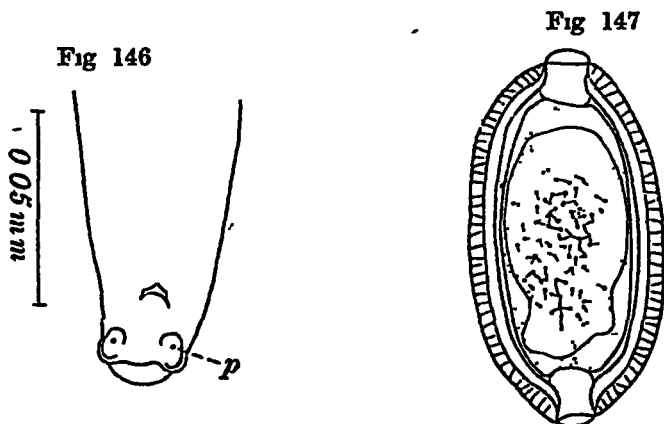


Fig 146 —*Capillaria hepatica* Posterior end of male, with spicule and sheath retracted, ventral view. *p*, papilla (After Baylis, in 'Parasitology')

Fig 147 —*Capillaria hepatica* Egg (After Baylis)

The outer layer of the shell is traversed by numerous minute rod-like structures, ending at the surface in refringent knobs or points. These structures give the shell, in optical section, a very characteristic radially-striated appearance.

The life-history of this species is direct. When infective eggs are swallowed by a suitable host, they hatch in the alimentary canal, especially in the cæcum. The larvæ then, according to Fulleborn (1924), burrow into the wall of the intestine and are carried to the liver by the blood-stream. It is not fully understood how, under natural conditions, the eggs escape from the liver of the host and reach the exterior, but it has been suggested, with great probability, that carnivorous animals play an important part in their dissemination by means of their droppings. Cannibalism on the part of the

hosts may, in the same way, be a factor in the spread of infection. Momma (1930) considers flies the chief disseminating agents. He finds that the eggs are not affected by passage through the intestine of flies or of cats, and that they can withstand drying for about a month. In eggs taken directly from the liver of the host the embryos take five or six months, at ordinary temperatures, to develop. Shorb (1931), however, found that after passage through the intestines of rats or cats they developed in 25-42 days at a temperature of 30° C.

### 3 *Capillaria bilobata* Bhalerao, 1933. (Fig 148)

Host.—Cattle (*Bos indicus*), Muktesar, United Provinces. The worms were found in the abomasum, among the contents and not attached to the lining.

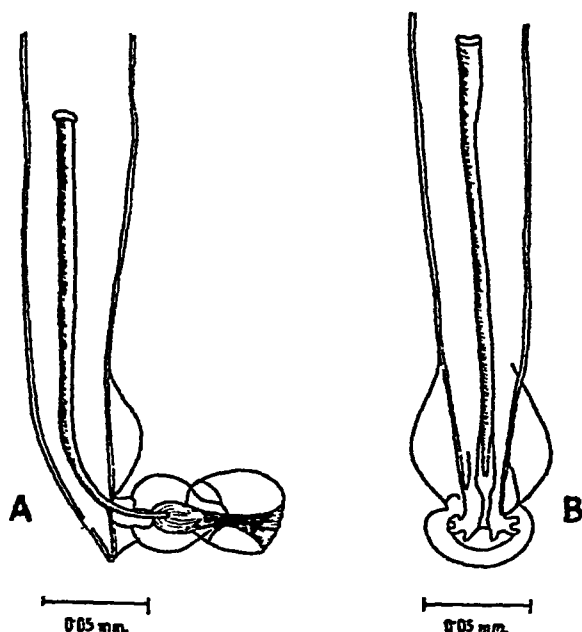


Fig 148—*Capillaria bilobata*. Posterior end of male. A, lateral view, B, ventral view. (After Bhalerao, in Indian Journ Vet Sci.)

The male measures 10.1-16.5 mm in length and 0.05-0.083 mm in maximum thickness, the female 14-21.3 mm and 0.072-0.085 mm respectively. "On the dorsal and ventral side of the body are situated the bacillary bands, which are narrow both anteriorly and posteriorly, but in the middle portion of the body for a considerable distance they increase

so much in width that they meet with each other and become continuous. In some cases the bands remain separate throughout the length of the body, and in others lateral bands have been observed." The œsophagus occupies less than half the total length of the body, measuring 5.2–8 mm. in the male and 6.5–9.4 mm in the female. The nerve-ring, in the male, is situated at 0.173–0.177 mm from the anterior end.

The caudal end of the male is provided with a bursa-like expansion into which project, according to Bhalarao's description, "four papillæ or peg-like processes, the lateral two of which are stouter and divided at their extremity into two digitations, and the other two are situated between the former." From the figure it appears that the structures referred to might be described as a pair of lateral processes each having three digitations. In front of the "bursa" there is a pair of lateral alæ measuring about 0.075 mm in length. The spicule is relatively very short, measuring 0.19–0.24 mm. in length and  $6.5\text{--}10\mu$  in thickness at its root, and "presents light transverse striations." The spicule-sheath is without spines or striations. When everted it is not more than 0.087 mm long and "appears to consist of two lobes, the terminal one of which is like an inverted bell and the other is pear-shaped," the narrow portion of the latter projecting into the former.

The vulva is situated at a distance of 0.055–0.075 mm behind the junction of the œsophagus and intestine. The vagina is muscular and measures about 0.24–0.25 mm in length. The eggs measure  $0.033\text{--}0.053 \times 0.014\text{--}0.021$  mm.

### *Capillaria* sp.

Moorthy (1938, c) describes immature forms, considered to be third-stage larvæ, of a species of *Capillaria* from the intestines of *Barbus puckelli*, *B. ticto* and *Lepidocephalichthys thermalis* in Mysore. They were found either embedded in the mucous membrane or encysted in the peritoneal layer of the midgut.

## APPENDIX.

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### GENERA AND SPECIES OF UNCERTAIN POSITION

#### 1 Genus *SCOLECOPHILUS* Baylis and Daubney, 1922

Body short and stout, tapering more gradually in front than behind. Cuticle thin and smooth. Lateral fields very conspicuous, broad, granular, increasing in width posteriorly and bending towards the ventral surface near the tail. Head truncate, without recognizable lips or papillæ. Oesophagus slender, with a large, oblong, glandular posterior bulb, connected with the intestine by a narrow neck containing some kind of valves. Intestine modified into a fat-body. Anus absent. Tail of male blunt, strongly curled ventrally. Caudal papillæ apparently absent. Two equal spicules present, broad at their roots and bent outwards at right angles in the middle, with their tips deeply bifurcate. An accessory piece present, with a triangular dorsal portion and two lateral processes. Vulva near the anterior end of the body. No muscular vagina. A single functional female genital tube present, running posteriorly. A blind sac, lying parallel to the anterior portion of this and acting as an egg-reservoir, probably represents a second uterine branch. Eggs oval, with a thin shell, containing a crescentic embryo *in utero*. Adult worms in the body-cavity of earthworms.

Genotype:—*Scolecophilus lumbricicola* Baylis and Daubney, 1922

#### 1 *Scolecophilus lumbricicola* Baylis and Daubney, 1922. (Figs 149 & 150)

*Host* —*Perionyx m'intoshi* (body-cavity), Nepal Valley

The male measures 3.65–4.15 mm in length and 0.4–0.5 mm in maximum thickness, the female 6–6.5 mm and 0.5–0.6 mm respectively. The width of the lateral fields is about 0.1 mm anteriorly, increasing posteriorly to about 0.22 mm. The cuticle covering them, especially near the extremities, is thrown into strongly-marked transverse furrows. The musculature is apparently of the meromyarian type. The total length of the oesophagus is 0.7–0.76 mm in the male and 0.8–0.9 mm in the female. The bulb measures about 0.35 mm.



The portion of the body anterior to it is usually much narrower than the rest of the body. The uterus runs back almost straight for about three-quarters of the length of the body, and the coils of the oviduct and ovary are confined to about the posterior third. A second uterine branch appears to

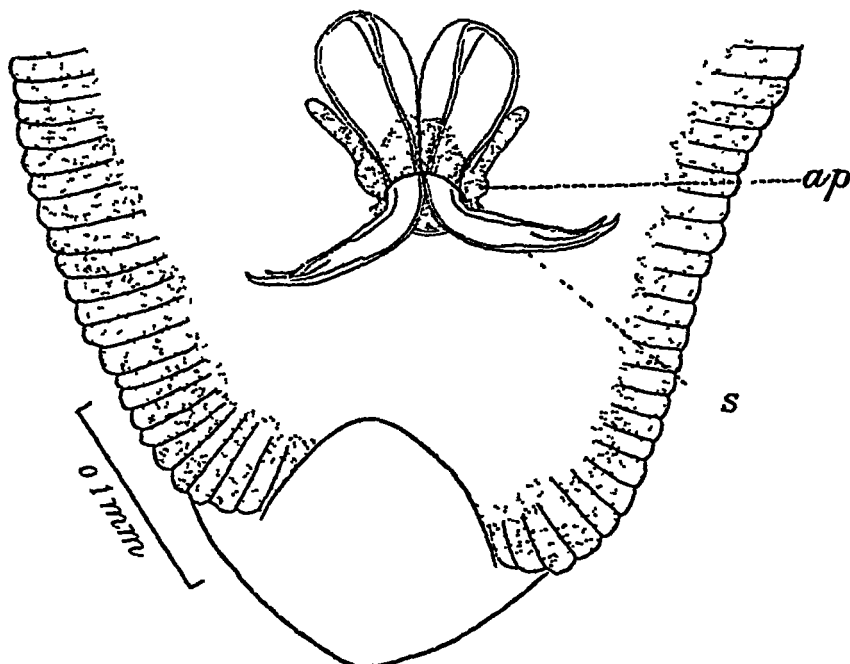


Fig 150—*Scolecophilus lumbricicola* Posterior end of male, ventral view *ap*, accessory piece, *s*, left spicule (After Bayls and Daubney)

be represented by a blind sac which may run back, in large specimens, to a point about 2.5 mm from the anterior end, and is usually full of eggs. These measure about  $0.065 \times 0.038$  mm.

## 2 Genus *UROLABES* Carter, 1859

Carter (1859, *b*) described a number of species which he referred to this genus. The genotype, *U. palustris*, has been doubtfully assigned to *Dorylaimus* (see vol 1, p 234), while *U. barbata* is regarded as probably a *Symplocostoma* (see vol 1, p 239) and *U. ocellata* a *Chromadora* (see vol 1, p 244). There remain seven forms whose position is quite uncertain, and, indeed, it is doubtful whether the species can be recognized. All except one of them are free-living forms. The following are summaries of Carter's descriptions, supplemented by reference to his figures.

1 *Urolabes glæocapsarum* Carter, 1859.

*Habitat* —“The *Glæocapsa* which grows on walls and on the sides of gutters during the ‘rains’”, Island of Bombay.

Length  $1/54$  in Thickness  $1/376$  in Head blunt, without papillæ Tail long, with a digital termination Buccal capsule cup-shaped anteriorly, narrow and cylindrical posteriorly Œsophagus with a median fusiform swelling and a posterior bulb. Vulva a little in front of the middle of the body. Female genital tubes paired, opposed

2 *Urolabes labiata* Carter, 1859.

*Habitat* —As for *U glæocapsarum*

Male unknown Female  $1/40$  in long and  $1/774$  in. thick Head “labiated and furnished with two papillæ” Buccal capsule tubular, cylindrical Œsophagus with median fusiform swelling and posterior bulb Vulva much behind the middle of the body, at about the last quarter Genital tube “probably unsymmetrical, there being no room for the posterior half, on account of the backward situation of the vulva”

3 *Urolabes tentaculata* Carter, 1859.

*Habitat* —As for *U glæocapsarum*

Male unknown Female about  $1/23$  in long and  $1/26$  [?] in. thick Head “obtuse and furnished with two short, thick, conical, tentacular prolongations, closely approximated at their base and turned outwards”\* Buccal capsule narrow, tubular Œsophagus with slight median fusiform swelling and posterior bulb Vulva just behind the middle. Genital tubes paired

4 *Urolabes cirrata* Carter, 1859

*Habitat* —As for *U glæocapsarum*

Male unknown Female  $1/73$  in long and  $1/1080$  in thick Head “obtuse and furnished with two linear short cirri widely separated” Buccal cavity, according to the figure, a short, cylindrical pharynx Œsophagus “gradually increasing in diameter backwards to its bulbous termination” Vulva in the posterior half of the body, a little in front of the posterior quarter Genital tubes undescribed ,

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\* In the figure the structure looks like a membranous funnel surrounding the mouth

### 5 *Urolabes erythrops* Carter, 1859

Synonym — *Enoplus erythrops* Eberth, 1863 \*

*Habitat* — "Silty clots of *Oscillatoria* floating in the salt-water main drain of the town of Bombay"

Length  $1/20$  in Thickness  $1/470$  in Head "obtuse and without papillæ" Buccal cavity apparently a funnel-shaped pharynx, with a globular posterior chamber. Œsophagus simple and club-shaped. A pair of globular ocelli present at about the anterior fifth of the Œsophagus, "of a rich carmine colour in their posterior three-fourths, and the anterior fourth or corneal portion bluish-opalescent" The caudal end of the male diminishes suddenly in thickness at the cloacal aperture, and the tail is more slender than that of the female. Spicules paired, broad. Tail of female very long and tapering. Vulva at about the middle of the body. Female genital tubes paired.

### 6 *Urolabes infrequens* Carter, 1859

*Habitat* — As for *U. erythrops*

"A little larger" than *U. erythrops*, which it closely resembles. Buccal cavity funnel-shaped, apparently without posterior globular chamber. Ocelli as in *U. erythrops*, but yellowish throughout. Tail of male short, conical and curved ventrally, "presenting on each side of the inner curvature a membranous expansion supported on setaceous ribs, which extends from the tip of the tail to some little distance above the anus". Spicules paired, broad. Tail of female long and tapering. Vulva and genital tubes as in *U. erythrops*. "Ova undergoing segmentation and the embryo developed in the ovisac, but not liberated there."

### 7 *Urolabes parasitica* Carter, 1859

Synonyms — "*Filaria*" of Carter, 1858, *Nematodum nautis albidæ* Diesing, 1861

*Habitat* — "Found singly and in variable plurality in the peritoneal cavity of *Nais albidæ*, which worm was met with in a species of *Glæocapsa* during the rainy season" (Carter, 1858, a), Bombay

Male unknown. Female  $1/43$  in long. Head "obtuse and without papillæ". Œsophagus apparently simple and club-shaped, "commencing in an expanded oral orifice, immediately becoming narrowed into a straight uniform tube, naked at the commencement" [i. e. a buccal capsule]. Vulva a little in front of the middle of the body. Genital tubes paired, opposed.

\* Mentioned without description, but evidently Carter's species

## ADDENDUM TO VOL. I.

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### Family QUIMPERIIDÆ Baylis, 1930 \*.

Ascaroidea Musculature meromyarian. Lips small or absent Buccal capsule absent Œsophagus muscular throughout, its anterior portion sometimes forming a "pharynx" No distinct œsophageal bulb, but the posterior portion of the œsophagus may be modified in structure and wider than the anterior portion A preanal sucker, without chitinous border, may be present in the male Spicules paired, equal Vulva in the posterior half of the body Uterine branches opposed Females oviparous.

#### 1. Genus PARAGENDRIA, nov. †

Mouth a shallow depression without definite lips. Teeth not observed at its base Œsophagus simple, club-shaped posteriorly Broad lateral alæ extend throughout almost the whole length of the body A preanal sucker present in the male No accessory piece observed Adult worms in the intestine of fishes

Genotype — *Paragendria macronis* (Stewart, 1914)

#### 1 *Paragendria macronis* (Stewart, 1914).

Synonyms — *Heterakis macronis* Stewart, 1914, *Subulura* (?) *macronis* Barreto, 1919

Host — *Macrones aor* (intestine), [Lucknow market]

The male measures about 3.65–7.41 mm in length and 0.148 mm in maximum thickness, the female about 6.6–8.5 mm and 0.129–0.153 mm respectively The worms are described as delicate and hair-like The anterior end is

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\* This family shows some evidences of relationship to the Katharinidæ (vol 1, p 158)

† From Stewart's (1914, a) description of the species placed here, it does not seem possible to assign it to any of the genera (*Quimperia* Gendre, 1926, *Gendria* Baylis, 1930, and *Paraquimperia* Baylis, 1934) at present included in the family It appears, however, to be fairly closely related to *Gendria*

usually curved dorsally. The cuticle is apparently unstriated. The "head" is rounded and very slightly wider than the "neck," having a diameter of 0.04–0.055 mm. There is a pair of broad lateral alæ, extending from the anterior extremity almost as far as the anus. Anteriorly the margins of these alæ are supported by cuticular thickenings. They attain a maximum width of about 0.048–0.067 mm. at the level of the posterior end of the œsophagus. There are no lips. The mouth is "formed by a shallow funnel-shaped depression in the anterior end of the œsophagus," and is surrounded by a ring of slightly thickened cuticle, which is somewhat thicker ventrally than dorsally, and tilted slightly towards the dorsal side. The œsophagus is about 0.75–0.85 mm. long, and is simple and club-shaped, without pharynx or bulb. Its walls are darkly pigmented behind the nerve-ring. This is situated at 0.314–0.425 mm., and the cervical papillæ at 0.56 mm., from the anterior extremity.

The caudal end of the male is curved ventrally. The tail measures 0.17–0.185 mm. in length, including a terminal spike 0.073 mm. long. A pair of caudal alæ extend from the preanal sucker to the base of the caudal spike (a distance of 0.44 mm.). There are five pairs of preanal and six pairs of postanal papillæ, and two median preanal papillæ, one of which is situated a little in front of the cloacal aperture, the other somewhat further forward. The most anterior pair of papillæ is situated considerably in front of the sucker. The second and third pairs of papillæ from the posterior end have very large and stout peduncles. The spicules measure 0.0765 mm. in length. They are hollow at their roots, where they measure  $6.8\mu$  in thickness. Distally each spicule is flattened and "bears five longitudinal ribs on its outer and posterior surface."

The tail of the female is tapering and measures 0.221–0.259 mm. in length. The vulva is situated at about the posterior third of the body (at 2.167–2.89 mm. from the posterior end). The eggs measure 0.051–0.0629  $\times$  0.037 mm.

**CLASSIFIED LIST OF HOSTS, with the Nematodes recorded from them in India, Ceylon and Burma, and described in this Work.**

Hosts marked thus (\*) are not native animals

**MAMMALS.**

**Order PRIMATES**

Man .	<i>Ascaris lumbricoides</i> , <i>Enterobius vermicularis</i> , <i>Strongyloides stercoralis</i> , <i>Ancylostoma duodenale</i> , <i>A. braziliense</i> , <i>Necator americanus</i> , <i>Trichostrongylus</i> ? <i>colubriiformis</i> , <i>Wuchereria bancrofti</i> , <i>Microfilaria malayi</i> , <i>M. actoni</i> , <i>Dracunculus medinensis</i> , <i>Gnathostoma spinigerum</i> (larva), <i>Trichinella spiralis</i> , <i>Trichuris trichiura</i> , <i>Capillaria hepatica</i>
<i>Hylobates hoolock</i>	<i>Probstmayria simæ</i> , <i>Strongyloides papillosus</i> , <i>Æsophagostomum blanchardi</i> , <i>O. ovatum</i> , <i>Dipetalonema</i> (?) <i>digitatum</i> , <i>Streptopharagus pigmentatus</i> , <i>Physocephaloides primus</i>
<i>Hylobates</i> sp	<i>Trichuris trichiura</i>
<i>Macacus rhesus</i>	<i>Strongyloides papillosus</i>
<i>Semnopithecus entellus</i>	<i>Trichuris trichiura</i>
<i>Semnopithecus obscurus</i>	<i>Æsophagostomum tridentatum</i>
<i>Loris lydekkerianus</i> [L. gracilis]	<i>Subulura sarasinorum</i>
* <i>Lemur</i> ? <i>brunneus</i>	(?) <i>Enterobius anthropopithecæ</i>
* <i>Lemur ruber</i>	<i>Protofilaria furcata</i>

**Order CARNIVORA**

Cat (domestic)	<i>Toxocara mystax</i> , <i>Toxascaris leonina</i> , <i>Strongyloides felis</i> , <i>Ancylostoma caninum</i> , <i>A. braziliense</i> , <i>Cylicospirura felinea</i> , <i>Physaloptera præputialis</i> , <i>P. brevispiculum</i> , <i>Gnathostoma spinigerum</i>
Cat, Siamese	<i>Toxocara mystax</i>
<i>Felis bengalensis</i>	<i>Toxocara mystax</i> , <i>Toxascaris leonina</i> , <i>Ancylostoma braziliense</i> , <i>Physaloptera præputialis</i>
<i>Felis chaus</i>	<i>Toxocara mystax</i> , <i>Physaloptera præputialis</i> , <i>P. masoodi</i>
<i>Felis leo</i>	<i>Toxascaris leonina</i> , <i>Ancylostoma braziliense</i>
<i>Felis nebulosa</i>	<i>Physaloptera præputialis</i>

<i>Felis pardus</i>	<i>Toxocara mystax</i> , <i>Toxascaris leonina</i> , <i>Ancylostoma caninum</i> , <i>A. braziliense</i> , <i>Galoncus perniciosus</i> , <i>Dracunculus</i> <i>medinensis</i> , <i>Physaloptera præputialis</i> , <i>Gnathostoma spinigerum</i> .
<i>Felis rubiginosa</i>	<i>Ancylostoma minimum</i> , <i>Physaloptera</i> <i>brevispiculum</i>
<i>Felis temminckii</i>	<i>Physaloptera brevispiculum</i>
<i>Felis tigris</i>	<i>Toxocara mystax</i> , <i>Toxascaris leonina</i> , " <i>Ascaris</i> " <i>tigridis</i> , <i>Ancylostoma duo-</i> <i>denale</i> , <i>A. caninum</i> , <i>A. braziliense</i> , <i>Gnathostoma spinigerum</i>
<i>Felis uncia</i>	<i>Toxascaris leonina</i>
<i>Felis viverrina</i> .	<i>Toxocara mystax</i> , <i>Toxascaris leonina</i> , <i>Ancylostoma duodenale</i> , <i>A. caninum</i> , <i>A. braziliense</i> , <i>Physaloptera præ-</i> <i>putialis</i>
" <i>Felis tigrinum</i> " . .	<i>Physaloptera præputialis</i> , <i>Gnathostoma</i> <i>spinigerum</i>
<i>Cynelurus jubatus</i>	<i>Toxascaris leonina</i>
<i>Viverricula malaccensis</i>	<i>Ancylostoma braziliense</i> , <i>Uncinaria longe-</i> <i>spiculum</i> , <i>Rictularia cahirensis</i>
<i>Paradoxurus hermaphro-</i> <i>ditus</i> ..	<i>Rictularia</i> sp
<i>Herpestes mungo</i>	<i>Spirura narayani</i> , <i>Rictularia</i> sp
<i>Dog (domestic)</i> .	<i>Ascaris lumbricoides</i> , <i>Toxocara canis</i> , <i>Toxascaris leonina</i> , (?) <i>Ancylostoma</i> <i>duodenale</i> , <i>A. caninum</i> , <i>Uncinaria</i> <i>stenocephala</i> , <i>Oslerus osleri</i> , <i>Diro-</i> <i>filaria immitis</i> , <i>D. repens</i> , <i>Dipetalon-</i> <i>nema reconditum</i> , <i>Microfilaria lewisii</i> , (?) <i>Dracunculus medinensis</i> , <i>Spiro-</i> <i>corca lupi</i> , <i>Thelazia callipæda</i> , <i>Gnatho-</i> <i>stoma spinigerum</i> , <i>Diectophyme renale</i>
<i>Canis aureus</i>	<i>Toxocara canis</i> , <i>Ancylostoma caninum</i>
<i>Canis pallipes</i>	<i>Toxocara canis</i> , <i>Ancylostoma caninum</i> , <i>A. braziliense</i>
<i>Cyon dukhunensis</i>	<i>Ancylostoma caninum</i> , <i>A. braziliense</i>
<i>Vulpes bengalensis</i>	<i>Toxocara canis</i> , (?) <i>Toxascaris leonina</i> <i>Ancylostoma caninum</i> , <i>Physaloptera</i> sp
<i>Vulpes leucopus</i>	<i>Ancylostoma caninum</i>
<i>Ursus malayanus</i>	<i>Ancylostoma malayanum</i>
<i>Ursus torquatus</i>	<i>Toxascaris transfuga</i> , <i>Ancylostoma</i> <i>malayanum</i> .
<i>Ursus</i> sp	<i>Toxascaris transfuga</i>
<i>Melursus ursinus</i>	<i>Toxascaris transfuga</i> , <i>Ancylostoma can-</i> <i>inum</i> , <i>A. braziliense</i> , (?) <i>A. malayanum</i>
<i>Ælurus fulgens</i>	<i>Toxascaris transfuga</i> , <i>Ancylostoma brazil-</i> <i>ense</i>
* <i>Procyon</i> sp	<i>Tetragomphus procyonis</i>

## Order INSECTIVORA

*Crocidura cærulea**Castronodus strasseni*



"Cattle" (mainly <i>Bos indicus</i> , but possibly including <i>B taurus</i> ) . . .	<i>Ascaris lumbricoides</i> , <i>A vitulorum</i> , <i>Esophagostomum columbianum</i> , <i>Bosicola radiatus</i> , <i>Chabertia ovina</i> , <i>Syngamus laryngeus</i> , <i>Bunostomum bovis</i> , <i>B phlebotomum</i> , (?) <i>Gaigeria pachyscelis</i> , <i>Ostertagia ostertagi</i> , <i>Hæmonchus contortus</i> , <i>H. similis</i> , <i>Mecistocirrus digitatus</i> , <i>Dictyocaulus viviparus</i> , <i>Onchocerca gibsoni</i> , <i>O lenalis</i> , <i>O armillata</i> , (?) <i>Parafilaria multipapillosa</i> , <i>Setaria cervi</i> , <i>S marshalli</i> , <i>Gongylonema pulchrum</i> , <i>G verrucosum</i> , <i>Thelazia rhodesii</i> , (?) <i>T lacrymalis</i> , <i>Trichuris ovis</i> , <i>T discolor</i> , <i>Capillaria bilobata</i>
Hybrid "bison" ( <i>Bos frontalis</i> × <i>B taurus</i> )	<i>Bosicola radiatus</i>
<i>Bos bubalus</i>	<i>Ascaris vitulorum</i> , <i>Bosicola radiatus</i> , <i>Syngamus laryngeus</i> , <i>Onchocerca gibsoni</i> , <i>O armillata</i> , <i>Setaria cervi</i> , <i>Gongylonema pulchrum</i> , <i>Thelazia rhodesii</i>
Sheep . . .	<i>Ascaris lumbricoides</i> , <i>Esophagostomum venulosum</i> , <i>O columbianum</i> , <i>Chabertia ovina</i> , <i>Bunostomum trigonocephalum</i> , <i>Gaigeria pachyscelis</i> , <i>Trichostrongylus colubriformis</i> , <i>T probolurus</i> , <i>Hæmonchus contortus</i> , <i>Nematodirus filicollis</i> , <i>Dictyocaulus filaria</i> , <i>Protostrongylus rufescens</i> , <i>Gongylonema pulchrum</i> , <i>G verrucosum</i> , <i>Trichuris ovis</i>
<i>Ovis hodgsoni</i>	<i>Dictyocaulus unequalis</i> , <i>Varestrongylus pneumonicus</i>
<i>Ovis nahura</i>	<i>Varestrongylus pneumonicus</i>
<i>Ovis vignei</i> . . .	<i>Gongylonema pulchrum</i>
Goat	<i>Bunostomum trigonocephalum</i> , <i>Protostrongylus rufescens</i> , <i>Gongylonema pulchrum</i> , <i>Trichuris ovis</i>
<i>Capra falconeri</i>	<i>Hæmonchus contortus</i>
<i>Capra sibirica</i>	<i>Esophagostomum venulosum</i> , <i>O asperum</i> , <i>Ostertagia circumcincta</i> , <i>O marshalli</i> , <i>O occidentalis</i> , <i>Hæmonchus contortus</i> , <i>Varestrongylus pneumonicus</i> , <i>Gongylonema verrucosum</i>
Antelope cervicapra	(?) <i>Trichuris ovis</i>
<i>Gazella bonneti</i>	<i>Dracunculus medinensis</i>
* <i>Cobus ellipsiprymnus</i>	<i>Bunostomum cobi</i>
<i>Cervus axis</i> . . .	<i>Esophagostomum indicum</i> , <i>Bosicola curvatus</i> , (?) <i>Hæmonchus contortus</i>
<i>Cervus elaphus</i> . . .	<i>Esophagostomum indicum</i>
<i>Cervus eldi</i>	<i>Trichuris ovis</i> , <i>T globulosa</i>
<i>Cervulus muntjac</i> . . .	<i>Gongylonema pulchrum</i>
<i>Tragulus javanicus</i>	<i>Esophagostomum traguli</i> , <i>Bosicola traguli</i> , <i>Papillosetaria reversa</i>

## Order UNGULATA (cont.).

Camelus dromedarius	Ostertagia mentulata, Hæmonchus longi stipes, Nematodirus mauritanicus, Dictyocaulus filaria, Dipetalonema evansi, Onchocerca fasciata, Thelazia leesei, "Trichuris cameli"
Pig (domestic)	Ascaris lumbricoides, Cruzia orientalis, Bourgelatia diducta, Oesophagostomum dentatum, O. quadrispinulatum, O. brevicaudum, O. maplestonei, Stephanurus dentatus, Globocephalus urosululatus, G. connorfilii, G. samoensis, Metastrongylus elongatus, Ascarops strongylina, Physocephalus sexalatus, Gnathostoma hispidum, G. doloresi, Trichuris trichiura
Sus cristatus	Ascaris lumbricoides, Ascaris sp., Ascarops strongylina, A. dentata, Physocephalus sexalatus, Gnathostoma hispidum, Trichuris trichiura

## Order CETACEA

Platanista gangetica	Contracaecum lobulatum
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## Order SIRENIA.

Halicore dugong	Dujardinia halicoris
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## Order EDENTATA

Manis pentadactyla	"Strongylus" costatus, Habronema zschokkei
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## BIRDS.

## Order PASSERES

Corvus splendens	"Filaria", vivipara
"Crow"	Chandlerella bosei
Urocissa erythrorhyncha occipitalis	Acuaria (A) anthuris
Urocissa flavirostris	Diplotriana urocissæ
Cissa chinensis	Hamulofilaria indica, Paraprocta brevicauda, Microfilaria cissæ, M. comma
Dendrocitta rufa	Paraprocta brevicauda, Acuaria (A) anthuris
Pyrhrocorax pyrrhocorax [Graculus eremita]	Diplotriana graculi, D. dubia, Acuaria (A) anthuris
Trochalopteron jerdoni meridionale	Diplotriana tricuspis
Saxicola sp.	"Filaria" abbreviata
Copsychus saularis	Aproctoides lissum, Paraprocta brevicauda, Acuaria (A) conica, A (A) brevispicula
Kittacincla malabarica [Kittacincla macroura]	"Spiroptera" sp.

<i>Dissemurus paradiseus</i>	<i>Chandlerella bosei</i> , <i>Paraprocta brevicauda</i> , <i>Microfilaria cephalocauda</i> , <i>M. colubroides</i>
<i>Oriolus ? chinensis diffusus</i> [ <i>O indicus</i> ] . . .	<i>Paraprocta brevicauda</i>
<i>Acridotheres ginginianus</i>	<i>Diplotriana tricuspidis</i>
<i>Acridotheres tristis</i>	<i>Diplotriana tricuspidis</i> , <i>D nagpurensis</i>
<i>Æthiopsar</i> [ <i>Acridotheres</i> ] <i>albocinctus</i> . . . .	<i>Diplotriana bharnoensis</i>

## Order CORACIIFORMES

<i>Brachypternus benghalensis</i> [ <i>B aurantius</i> ]	<i>Acuaria</i> ( <i>Synhumantus</i> ) <i>nana</i>
<i>Centropus sinensis</i>	<i>Ascaridia trilabium</i>
<i>Coracias benghalensis indica</i>	<i>Paraprocta brevicauda</i> , <i>Habronema indicum</i>
* <i>Ceryle alcyon</i>	<i>Acuaria</i> ( <i>Rusguniella</i> ) <i>brevis</i>
* <i>Halcyon</i> [ <i>Ceryle</i> ] <i>smyrnensis</i> .	<i>Quasithelazia tenuis</i>
<i>Otus sunia</i> [ <i>Scops pennatus</i> ]	<i>Habronema umbricatum</i>
<i>Ninox scutulata</i> .	" <i>Spiroptera</i> " <i>fei</i>

## Order ACCIPITRES

<i>Ægyptius monachus</i>	<i>Porrocaecum depressum</i>
" <i>Vulture</i> " . . .	<i>Porrocaecum angusticolle</i>
<i>Haliaeetus leucogaster</i>	<i>Contractaecum haliaeti</i>
<i>Icthyophaga ichthyaetus</i>	<i>Contractaecum haliaeti</i>
<i>Icthyophaga nana plumbeus</i> [ <i>Polioaetus plumbeus</i> ]	<i>Habronema magnilabiatum</i>
<i>Haliastur indus</i>	<i>Contractaecum haliaeti</i>
<i>Milvus migrans govinda</i>	<i>Porrocaecum angusticolle</i>
<i>Circus macrourus</i> .	<i>Habronema asymmetricum</i>
<i>Circus pygargus</i> [ <i>C cinereus</i> ]	<i>Physaloptera alata</i>
<i>Astur badius</i>	<i>Acuaria</i> ( <i>A.</i> ) <i>indica</i>
" <i>Fish-hawk</i> "	<i>Porrocaecum angusticolle</i>

## Order COLUMBÆ

" <i>Pigeon</i> "	<i>Ascaridia columbæ</i> , <i>Microfilaria columbæ</i> <i>Capillaria columbæ</i>
<i>Crocopus phoenicopterus</i>	<i>Ascaridia columbæ</i>
<i>Chalcophaps indica</i> .	<i>Ornithostrongylus travassosi</i>
* <i>Phlogoenas luzonica</i> .	<i>Ascaridia columbæ</i>

## Order PTEROCLETES

<i>Pterocles exustus</i>	<i>Syphaciella indica</i>
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## Order GALLINÆ

<i>Pavo cristatus</i>	<i>Pseudaspidodera pavonis</i> , " <i>Spiroptera</i> " sp
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## Order GALLINÆ (cont.)

<i>Pavo muticus</i> ..	<i>Heterakis hamulus</i> , <i>Pseudaspidodera pavonis</i> , <i>Habronema bulbosum</i>
<i>Argusianus argus</i> .	<i>Pseudaspidodera pavonis</i> , <i>P. voluptuosa</i> , <i>P. spinosa</i> , <i>Thylaconema sigmura</i>
<i>Polyplectron bicalcaratum</i>	<i>Heterakis isolonche</i> , <i>Paraprocta brevicauda</i> , <i>Habronema euplocami</i>
Fowl (domestic)	<i>Heterakis gallinæ</i> , <i>H. indica</i> , <i>H. beramporia</i> , <i>Ascaridia galli</i> , <i>Syngamus trachea</i> , <i>Gongylonema ingluvicola</i> , <i>Acuaria (Cheilospirura) hamulosa</i> A ( <i>Dispharynx</i> ) <i>spiralis</i>
<i>Gallus lafayetii</i> . . . . .	<i>Heterakis pusilla</i>
<i>Gallus sonnerati</i>	<i>Heterakis beramporia</i>
* <i>Phasianus torquatus</i>	<i>Heterakis gallinæ</i>
<i>Chrysolophus pictus</i> .	<i>Heterakis gallinæ</i>
<i>Lophura rufa</i> . . .	<i>Heterakis gallinæ</i> , <i>H. isolonche</i>
<i>Gennæus [Euplocamus] leucomelanos</i>	<i>Heterakis gallinæ</i> , <i>H. isolonche</i> , <i>Habronema euplocami</i>
<i>Gennæus nycthemerus</i>	<i>Heterakis gallinæ</i> , <i>H. pavonis</i> , <i>H. parva</i> , <i>H. isolonche</i> , <i>H. papillosa</i> , <i>H. beramporia</i>
<i>Lophophorus impejanus</i>	<i>Heterakis gallinæ</i> , <i>H. isolonche</i>
<i>Tragopan satyra</i>	<i>Heterakis gallinæ</i> , <i>H. bosia</i> , <i>H. isolonche</i>
<i>Ithaginis cruentus</i>	<i>Heterakis isolonche</i> , <i>Ascaridia galli</i>
<i>Galloperdix spadicea</i>	<i>Heterakis gallinæ</i> , <i>Subulura galloperdicis</i>
<i>Rollulus rouloul</i> .	<i>Pseudaspidodera voluptuosa</i> , <i>Subulura multipapillata</i> , <i>Acuaria (A.) lata</i>
<i>Arborophila atrogularis</i>	<i>Paraprocta brevicauda</i>
<i>Arborophila torqueola</i>	<i>Heterakis gallinæ</i> , <i>H. volvolabiata</i>
<i>Alectoris græca chukar</i>	<i>Heterakis gallinæ</i> , <i>Ascaridia compar</i>
<i>Francolinus gularis</i>	<i>Heterakis gallinæ</i>
* <i>Acryllium vulturinum</i>	<i>Heterakis gallinæ</i> , <i>Habronema diesingi</i>

## Order HEMIPODII

<i>Turnix dussumieri</i>	<i>Subulura turnicis</i>
<i>Turnix sp.</i>	<i>Subulura turnicis</i>

## Order GRALLÆ

<i>Metopidius indicus</i> .	<i>Acuaria (Dispharynx) spiralis</i>
<i>Grus grus</i> . .	<i>Porrocaecum ardeæ</i> , <i>Ascaridia stroma</i>
<i>Antigone antigone</i>	<i>Ascaridia cristata</i> , <i>A. stroma</i>
<i>Anthropoides virgo</i> .	<i>Porrocaecum ardeæ</i>
* <i>Balearica pavonina</i>	<i>Ascaridia cristata</i>
<i>Chlamydotis undulata macqueenii</i> .	<i>Heterakis gallinæ</i>

## Order STEGANOPODES

<i>Phalacrocorax fuscicollis</i> .	<i>Contracæcum spiculigerum</i>
<i>Phalacrocorax niger</i>	<i>Contracæcum spiculigerum</i>

- Anhinga melanogaster*.... (?) *Contracæcum* *spiculigerum*, *C. tri-*  
*cuspe*, *Acuaria* *macrolaima*, "*Spiro-*  
*ptera*" *secretoria*

## Order HERODIONES

- Threskiornis melanocephalus* *Belanisakis* *ibidis*  
*Ciconia nigra* . . . *Contracæcum* *engonium*  
*Leptoptilos dubius* *Acuaria* (*Echinuria*) *hargilæ*.  
*Ardea purpurea manillensis* *Porrocæcum* *reticulatum*  
*Bubulcus ibis coromandus* *Pseudamidostomum* *boulengeri*, *Acuaria*  
(*Synhumantus*) *invaginata*, *Microtetra-*  
*meres spiralis*  
" Egret " . *Porrocæcum* *reticulatum*.  
*Ardeola grayi* . . . *Contracæcum* *microcephalum*  
*Nycticorax nycticorax* *Porrocæcum* *reticulatum*, *Contracæcum*  
*rosarium*

## Order ANSERES

- Sarkidiornis melanotos* . *Epomidiostomum* *uncinatum*.  
*Nettapus coromandelianus* *Pseudamidostomum* *boulengeri*.  
*\*Cereopsis novæ hollandiæ* *Heterakis* *papillosa*  
*Casarca ferruginea* . *Epomidiostomum* *uncinatum*  
*Duok* (domestic) . *Porrocæcum* *crassum*  
*Dafila acuta* . . . *Epomidiostomum* *uncinatum*.  
*Querquedula querquedula* *Amidostomum* *skrjabini*, *Epomidiosto-*  
*mum uncinatum*.  
*Nyroca ferina* . . *Amidostomum* *skrjabini*, *Tetrameres*  
*spinosa*  
*Nyroca fulgula* . *Amidostomum* *skrjabini*.  
*Nyroca rufa* [*N. nyroca*] *Epomidiostomum* *uncinatum*.

## Order RHEIFORMES

- \*Rhea americana* . . . *Deletrocephalus* *dimidiatus*

## Order CASUARIFORMES

- \*Casuarius bicarunculatus* . *Habronema* *casuarii*

## REPTILES.

## Order EMYDOSAURIA.

- Gavialis gangeticus* . . *Dujardinia* *woodlandi*, (?) *Multicæcum*  
*agile*, *Polycæcum* *gangeticum*, *Typhlo-*  
*phoros lamellaris*, *Goezia* *gavialidis*,  
*Micropleura* *vivipara*  
*Crocodilus porosus* . . *Ascaris* *quadrata*, *Dujardinia* *helicina*

## Order TESTUDINES

- Chelonia mydas* . . . *Kathlamia* *leptura*, *Tonaudia* *tonaudia*  
*Geoemyda trijuga* *Spirochoura* *falcata*  
*Morenia ocellata* . *Camallanus* *sp*  
*Hardella thurgt* . . . *Spirochoura* *stewarti*.

## Order TESTUDINES (cont.)

<i>Kachuga kachuga</i>	<i>Spironoura falcata</i> , <i>Monhysterides kachuga</i>
<i>Kachuga smithi</i>	<i>Spironoura stewarti</i> , <i>Camallanus kachuga</i>
<i>Testudo elongata</i>	<i>Spironoura testudinis</i> , <i>Zanclophorus kemp</i> , <i>Atractis granulosa</i>
<i>Testudo emys</i> ...	<i>Spironoura onama</i> , <i>Cissophyllus lav erani</i> , <i>Atractis granulosa</i>
<i>Testudo travancorica</i>	<i>Zanclophorus annandalei</i>
<i>Testudo</i> sp ..	" <i>Heterakis</i> " <i>fea</i>
<i>Lissemys punctata granosa</i> [ <i>Emyda granosa intermedia</i> ]	<i>Spiroxys torquata</i> [?= <i>S annulata</i> ]
<i>Chitra indica</i> .	<i>Spiroxys annulata</i>
<i>Trionyx gangeticus</i>	<i>Spiroxys gangetica</i> , <i>Cucullanus serratus</i>

## Order SQUAMATA

## Suborder SAURIA

<i>Hemidactylus flaviviridis</i>	<i>Thelandros hemidactylus</i> , <i>Physaloptera</i> sp (larva), <i>Thubunæa dactyluris</i>
<i>Hemidactylus leschenaulti</i>	" <i>Oxyuris</i> " <i>megaloon</i>
<i>Cophotis ceylanica</i>	<i>Spinicauda cophotis</i>
<i>Lyriocephalus scutatus</i>	<i>Spinicauda cophotis</i>
<i>Calotes calotes</i> [C ophiomachus]	<i>Polydelphis rotundicaudata</i> , " <i>Spiroptera</i> " <i>triangulum</i>
<i>Calotes emma</i>	" <i>Filaria</i> " <i>emmae</i>
<i>Calotes nigrilabris</i>	<i>Strongyluris calotis</i>
<i>Calotes versicolor</i>	" <i>Ascaris</i> " <i>brachyura</i> , <i>Thelandros maplestoni</i> , <i>Conspicuum flavescens</i> , <i>Physaloptera achari</i> [?= <i>P paradoxa</i> ], <i>Physaloptera</i> sp, <i>Thubunæa dactyluris</i>
<i>Calotes</i> sp .	" <i>Oxyuris</i> " sp
<i>Uromastix hardwicki</i>	<i>Thelandros micruris</i> , <i>T baylisi</i> , <i>T taylori</i> , <i>T kasauli</i>
* <i>Iguana</i> sp	<i>Atractis opeatura</i>
* <i>Chamaeleon chamaeleon</i>	<i>Strongyluris chamaeleonis</i>
<i>Chamaeleon zeylanicus</i>	<i>Polydelphis</i> sp
<i>Mabuya carinata</i> .	" <i>Filaria</i> " <i>tuberosa</i>
<i>Varanus flavescens</i>	<i>Tanqua tiara</i>
<i>Varanus indicus</i>	<i>Physaloptera varani</i> , <i>P. ? paradoxa</i>
<i>Varanus monitor</i> [V bengalensis]	<i>Africana varani</i> , <i>Kalcephalus indicus</i> , <i>Tanqua tiara</i> , <i>Physaloptera varani</i> , <i>P paradoxa</i>
<i>Varanus nebulosus</i>	<i>Tanqua tiara</i>
<i>Varanus salvator</i>	<i>Amphicæcum varani</i> , <i>Hastospiculum macrophallos</i> , <i>Tanqua tiara</i>
<i>Varanus</i> sp	(?) <i>Dracunculus medinensis</i>

## Suborder SERPENTES

<i>Typhlops braminus</i> .	(?) <i>Kalicephalus willeyi</i>
<i>Python molurus</i> . . . . .	<i>Ophidascaris filaria</i> , <i>Polydelphis anoura</i> , <i>P. attenuata</i> , (?) <i>P. oculata</i> , <i>Kalicephalus orsili</i>
<i>Python reticulatus</i> . . . . .	<i>Ophidascaris filaria</i> , <i>Polydelphis attenuata</i> , <i>P. oculata</i> , (?) <i>Gnathostoma spinigerum</i> (larva)
<i>Gongylophis conicus</i> .	<i>Kalicephalus longior</i> .
<i>Ptyas</i> [ <i>Zamenis</i> ] <i>mucosus</i>	<i>Kalicephalus indicus</i> , <i>K. elongatus</i> , <i>K. brachycephalus</i> , <i>Camallanides prashadi</i>
<i>Coluber holena</i> . . . . .	(?) <i>Kalicephalus willeyi</i>
<i>Coluber</i> sp . . . . .	<i>Physaloptera</i> sp (larva)
<i>Tropidonotus piscator</i> .	<i>Ophidascaris gestri</i> , <i>Polydelphis brachycheilus</i> , <i>P. sewelli</i> , <i>Kalicephalus indicus</i> , <i>Tanqua anomala</i>
<i>Tropidonotus stolatus</i> . . . . .	<i>Polydelphis sewelli</i>
<i>Dryophis myeterizans</i> . . . . .	<i>Kalicephalus indicus</i>
<i>Bungarus bungaroides</i> .	<i>Ophidascaris naja</i>
<i>Bungarus fasciatus</i> .	<i>Ophidascaris naja</i> , (?) <i>Polydelphis sewelli</i> , (?) <i>Kalicephalus willeyi</i> , <i>Kalicephalus longior</i> , <i>K. minutus</i> , <i>K. fimbriatus</i> , (?) " <i>Filaria</i> " <i>haje</i> , <i>Camallanides prashadi</i>
<i>Naja hannah</i> . . . . .	<i>Kalicephalus indicus</i> , <i>K. longior</i> , (?) <i>Gnathostoma spinigerum</i> (larva), <i>Camallanides prashadi</i>
<i>Naja tripudians</i> . . . . .	<i>Ophidascaris naja</i> , <i>Kalicephalus indicus</i> , <i>K. longior</i> , <i>K. elongatus</i> , <i>K. minutus</i> , <i>Kalicephalus</i> sp, (?) " <i>Filaria</i> " <i>haje</i> , " <i>Filaria</i> " sp, (?) <i>Dracunculus medinensis</i> , (?) <i>Gnathostoma spinigerum</i> (larva)
<i>Vipera russelli</i> . . . . .	<i>Kalicephalus willeyi</i> , <i>Physaloptera</i> sp
<i>Trimeresurus gramineus</i> . . . . .	<i>Polydelphis</i> sp
"Snake" . . . . .	<i>Physaloptera</i> sp (larva)

## AMPHIBIA.

## Order SALIENTIA.

<i>Rana hexadactyla</i> . . . . .	<i>Spironoura brevispiculata</i>
<i>Rana tigrina</i> . . . . .	<i>Oxysomatium macintoshii</i> , <i>Camallanus baylisi</i> , <i>Camallanides prashadi</i>
<i>Bufo melanostictus</i> . . . . .	<i>Heterakis govindi</i> , <i>Oxysomatium macintoshii</i> , <i>Oswaldocruzia filiformis</i> , " <i>Spiroptera</i> " sp (larva)
<i>Bufo stomaticus</i> . . . . .	<i>Oxysomatium macintoshii</i> , <i>Physaloptera</i> sp (larva)

## Order GYMNOPTIONA

<i>Uraeotyphlus oxyurus</i> . . . . .	<i>Rhabdias escheri</i>
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## FISHES.

## Order PLAGIOSTOMATA

<i>Galeocerdo tigrinus</i> . . . .	<i>Porrocæcum galeocerdonis</i>
<i>Cetorhinus maximus</i> .	<i>Contracæcum plagiostomorum</i>
<i>Chiloscyllium indicum</i>	<i>Kathlamia chiloscyllii</i>
<i>Acanthias vulgaris</i> .	<i>Proleptus obtusus</i>
<i>Pristis perrotteti</i> . . .	<i>Porrocæcum pristis</i>
<i>Raja radiata</i>	<i>Contracæcum plagiostomorum</i>
<i>Urogymnus asperimus</i>	<i>Echinocephalus spinosissimus</i> , <i>E southwelli</i> , <i>E multidentatus</i>
<i>Urogymnus</i> sp .	<i>Echinocephalus southwelli</i>
<i>Trygon pastinaca</i>	<i>Paranisakis pastinacæ</i> , <i>Echinocephalus uncinatus</i>
<i>Trygon sephen</i> .	<i>Echinocephalus spinosissimus</i>
<i>Trygon walga</i>	<i>Echinocephalus spinosissimus</i>
<i>Tænura melanospilos</i> .	<i>Paranisakis pastinacæ</i>
<i>Tænura</i> sp .	<i>Paranisakis pastinacæ</i>
<i>Myliobatis nieuhofti</i>	<i>Echinocephalus uncinatus</i>
<i>Aëtobatis narinari</i> .	<i>Proleptus obtusus</i>

## Order PHYSOSTOMI

<i>Clarias magur</i> [C batrachus]	<i>Gnathostoma spinigerum</i> (larva), <i>Procamallanus planoratus</i>
<i>Saccobranchus fossilis</i>	<i>Gnathostoma ? spinigerum</i> (larva)
<i>Wallago attu</i>	(?) <i>Porrocæcum</i> or <i>Anisakis</i> sp (larva), <i>Contracæcum</i> sp (larva), <i>Spinitectus minor</i> , <i>Procamallanus mehri</i>
<i>Eutropuchthys vacha</i>	<i>Spinitectus indicus</i>
<i>Callichrous macrophthalmus</i>	<i>Cucullanus callichroi</i> .
<i>Callichrous pabda</i>	(?) <i>Porrocæcum</i> or <i>Anisakis</i> sp (larva), <i>Contracæcum</i> sp (larva)
<i>Pseudotropius garua</i> .	<i>Spinitectus indicus</i>
<i>Macrones aor</i> .	<i>Paragendria macrones</i>
<i>Lepidocephalichthys thermalis</i> . . . .	<i>Camallanus sweeti</i> (larva), <i>Camallanid larva</i> , <i>Capillaria</i> sp (larva)
<i>Barbus puckelli</i>	<i>Camallanus sweeti</i> (larva), <i>Camallanid larva</i> , <i>Capillaria</i> sp (larva)
<i>Barbus ticto</i>	<i>Camallanus sweeti</i> (larva), <i>Capillaria</i> sp. (larva)
<i>Barbus tor</i> . . . .	<i>Spironoura barbi</i> , <i>S leptocephala</i> , <i>Monhysterides piscicola</i>
<i>Barilius bola</i> . .	<i>Contracæcum</i> sp (larva)
* <i>Gambusia</i> sp . .	<i>Camallanus sweeti</i> (larva).

## Order ACANTHOPTERYGII

(?) <i>Lethrinus</i> sp .	" <i>Filaria</i> " <i>piscicola</i>
<i>Otolithus maculatus</i> . . .	<i>Porrocæcum</i> sp (larva)
<i>Histiophorus gladius</i> . . . .	<i>Contracæcum incurvum</i>

<i>Trichiurus savala</i>	<i>Contracaecum trichiuri</i>
<i>Caranx melampygus</i>	<i>Cucullanus bulbosus</i>
<i>Platax teira</i>	" <i>Ascaris</i> " <i>meleagrinae</i>
<i>Dysalotus alcocki</i>	<i>Porrocaecum</i> or <i>Anisakis</i> sp (larva)
<i>Ophiocephalus gachua</i>	<i>Spinitectus corti</i> , <i>Camallanus sweeti</i> , <i>Camallanid</i> larva
<i>Ophiocephalus striatus</i> ...	<i>Gnathostoma spinigerum</i> (larva)

## Order PLECTOGNATHI

<i>Balistes mitis</i>	<i>Contracaecum balistis</i> (larva), " <i>Ascaris</i> " <i>meleagrinae</i> , " <i>A</i> " <i>balisticola</i> , <i>Echino-</i> <i>cephalus uncinatus</i> (larva)
<i>Balistes stellaris</i>	<i>Contracaecum balistis</i> (larva), " <i>Ascaris</i> " <i>meleagrinae</i> , " <i>A</i> " <i>balisticola</i> , <i>Echino-</i> <i>cephalus uncinatus</i> (larva)
<i>Balistes</i> sp	<i>Phulometra</i> sp
<i>Diodon hystrix</i>	<i>Raphidascaris diadonis</i>

## INSECTS.

## Order DIPTERA

<i>Musca domestica</i>	<i>Habronema muscae</i> (larva)
<i>Anopheles barbirostris</i>	<i>Mermis</i> sp (larva)
<i>Anopheles annularis</i> [ <i>A. ful-</i> <i>ginosus</i> ]	<i>Mermis</i> sp (larva)
<i>Anopheles sundanicus</i> [ <i>A. lud-</i> <i>lowi</i> ]	<i>Wuchereria bancrofti</i> (larva)
<i>Anopheles varuna</i>	<i>Mermis</i> sp (larva)
<i>Anopheles ramsayi</i> [ <i>A. pseu-</i> <i>dojamesu</i> ]	<i>Mermis</i> sp (larva)
<i>Anopheles hyrcanus</i> var <i>sinensis</i>	<i>Mermis</i> sp (larva)
<i>Anopheles philippinensis</i>	<i>Mermis</i> sp (larva), <i>Wuchereria bancrofti</i> (larva)
<i>Anopheles subpictus</i>	<i>Mermis</i> sp (larva)
<i>Anopheles tessellatus</i>	<i>Mermis</i> sp (larva)
<i>Culex fatigans</i>	<i>Wuchereria bancrofti</i> (larva), <i>Coni-</i> <i>spiculum flavescens</i> (larva)

## Order LEPIDOPTERA.

<i>Papilio helenus</i>	<i>Mermis indica</i> (larva)
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## MYRIOPODA.

<i>Julus</i> sp	" <i>Oxyuris</i> " <i>longicaudata</i>
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## CRUSTACEA.

<i>Uca manu</i>	<i>Rhabdochona uca</i>
"Prawn"	(?) <i>Eustrongylides</i> sp (larva)
<i>Cyclops hyalinus</i>	<i>Dracunculus medunensis</i> (larva), <i>Camal-</i> <i>lanus sweeti</i> (larva)

CRUSTACEA (*cont* )

Cyclops leuckarti .	Dracunculus medinensis (larva), Camallanus sweeti (larva), Camallanus sp (larva)
Cyclops vermifer	Dracunculus medinensis (larva)
Cyclops sp	Gnathostoma spinigerum (larva)

## MOLLUSCA.

Margaritifera vulgaris	" Ascaris " melcagrinae (larva), " Oxyuris " sp, Echinocephalus uncinatus (larva)
Pinna sp	Echinocephalus uncinatus (larva)

## ANNELIDA.

Nais albida .	Urolabes parasitica
Perionyx m'intoshii .	Scolecophilus lumbricicola.

## CORRECTION TO VOL. I.

In the key to species of *Subulura*, p 151, for " spicules " (lines 3, 4, 5, 7) read " tail of female ", for " ten " (line 6) read " eleven "

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